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SCIENCE

16 December 1960
Vol. 132, No. 3442

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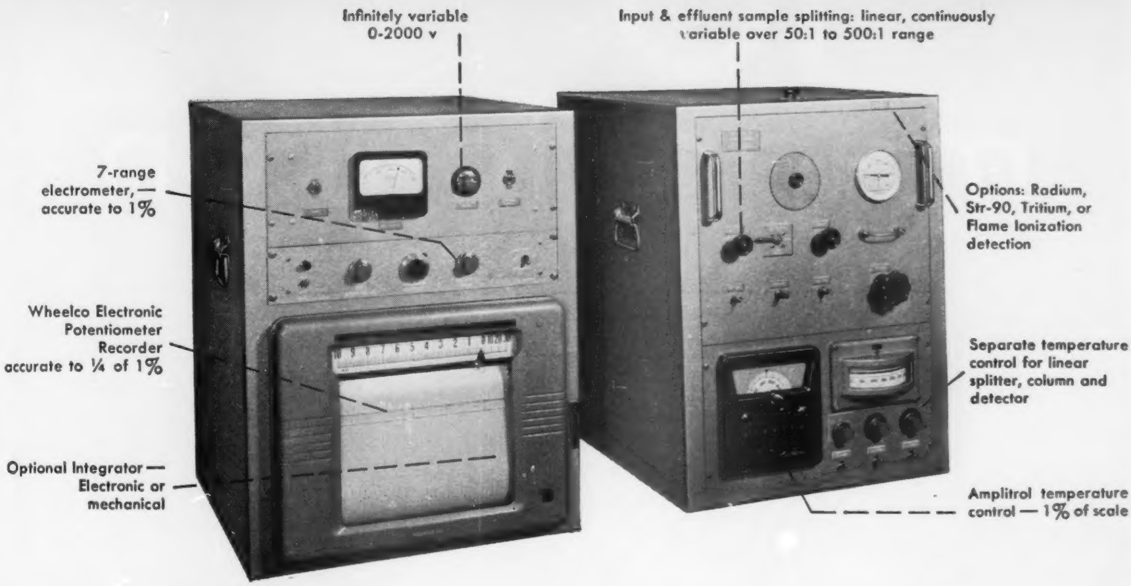

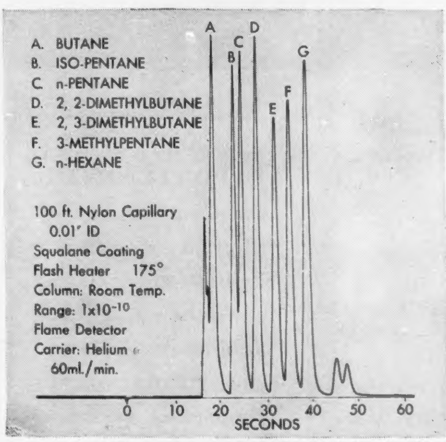

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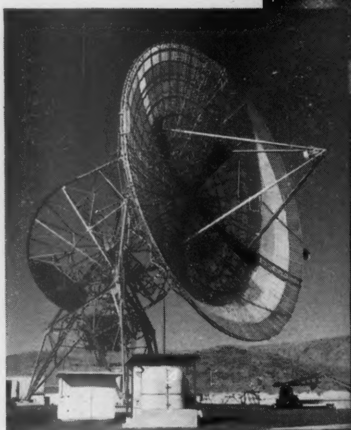
16 December 1960, Volume 132, Number 3442

SCIENCE

Cover Underwater sedimentary formations in Moriches Inlet off the south shore of Long Island, photographed from an airplane. From *The Intelligent Man's Guide to Science* by Isaac Asimov; see page 1830. [American Geographical Society and Basic Books]

Pioneering Achievements at JPL

Following an impressive period, beginning in 1938, in the pioneering and development of all forms of rocketry—JPL's jump into outer space began with the successful flight of America's first satellite, Explorer I. When the moon probes Pioneer III and IV proved equally successful, the Jet Propulsion Laboratory's position as an outstanding center of research and development was again confirmed.



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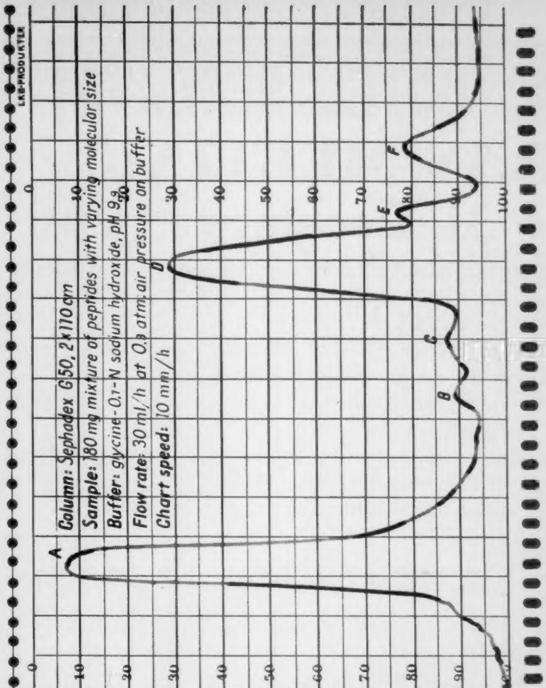

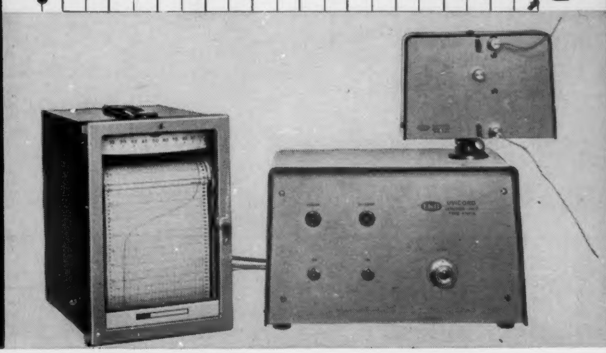

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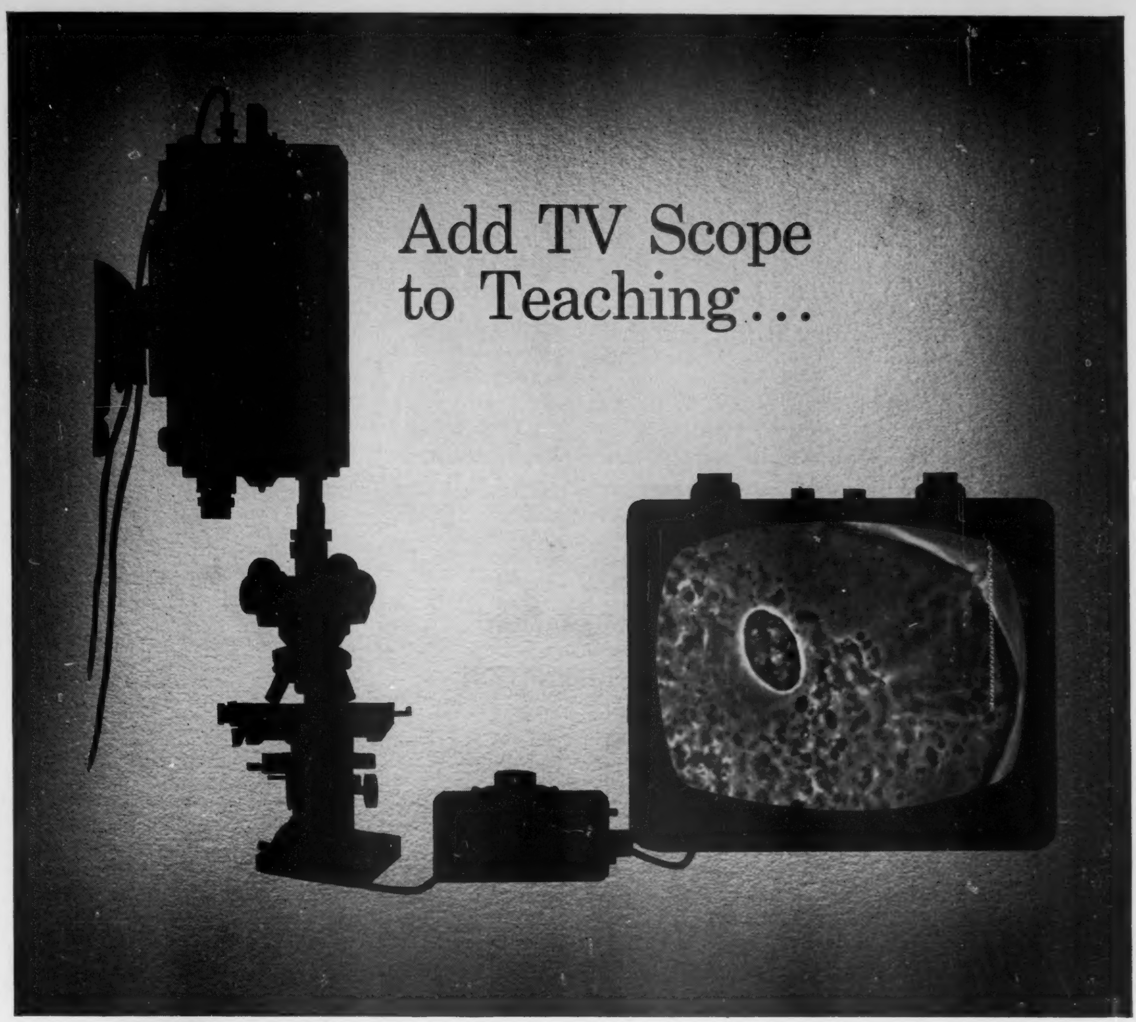

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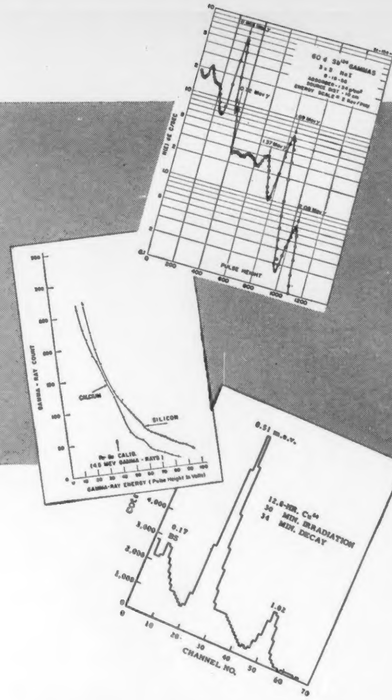

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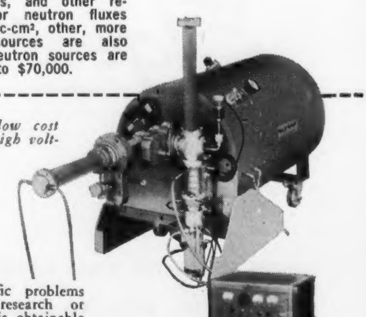

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Social Science

The National Science Foundation has established a Division of Social Sciences, correlative with the divisions responsible for supporting work in the physical and biological sciences. Establishment of the new division concludes a debate that began in 1946 when Congress first discussed the creation of a National Science Foundation. Some of the Congressional bills included a Division of Social Sciences; others excluded it. The final compromise was to omit specific mention of the social sciences but to give the foundation an open-ended structure by attaching the words ". . . and other sciences" to each listing of fields in which research grants, fellowships, or other support might be given. What Congress said, in essence, to the new Foundation was: "We do not instruct you to support work in the social sciences and neither do we prohibit such work; we leave the decision in your hands."

This action was satisfactory to most scientists; indeed a number of social scientists recommended that their fields not be specifically mentioned so that the controversy might be settled and the Foundation brought into being. A poll conducted by the Inter-Society Committee for a National Science Foundation, which the AAAS established in 1947 to determine and make known the consensus of scientists with respect to the several organizational problems at issue, showed 49 percent of the scientists queried as favoring inclusion of the social sciences, 2 percent opposed, and 48 percent preferring to leave the decision to the Foundation itself. Ninety-eight percent were willing either to have a Division of Social Sciences written into the bill or to have the question decided by the Foundation itself; and 63 percent said they would prefer no foundation to one from which the social sciences were excluded by statute.

In the light of its legislative history, the NSF approached the social sciences gradually. From the very beginning, fellowships in the more biological aspects of anthropology and psychology were awarded. This was not support for the social sciences, but the action gave substance to the ". . . and other sciences" portion of the mandate. Later, research was supported in those areas of the social sciences that converge with the physical or biological sciences. Still later, these programs were expanded and brought together in an Office of Social Sciences. Now the Office has become a Division. What the Foundation has done, in essence, is to reply to Congress: "We have explored carefully the means of social science support we consider proper and have now decided that full recognition, through divisional status, is desirable."

Social scientists will be pleased, and so, unless majority opinion has changed since 1947, will most other scientists; pleased both with the symbolic value of the new status and with the promise of increased support that accompanied the NSF action. Support, the NSF has pointed out, will be for basic research that meets high standards of conceptual and methodological rigor, not for "applied craftsmanship in social affairs." This is as it should be, to be consistent with other programs of the NSF, to allay any remaining fears that the term *social science* is merely a cloak for action on important but sometimes controversial social issues, and to help competent research scholars interested in human and social behavior to develop their field to the point where there will no longer be any doubts concerning the appropriateness of the word *science* in *social science*.—D.W.

16 December 1960, Volume 132, Number 3442 SCIENCE

CURRENT PROBLEMS IN RESEARCH

The Chilean Earthquakes of May 1960

Studies of the disaster increase our understanding of earth shocks and of ways to withstand them.

C. Martin Duke

An event of great engineering and scientific interest occurred in south-central Chile last May, when that active portion of the globe was devastated by an earthquake of magnitude 8.5. Besides the major shock, there were several others of destructive effect. A tsunami, or tidal wave, was created, causing widespread loss of life and property on far-flung shores of the Pacific Ocean. A volcano erupted. Tectonic movements occurred. Soft soils were violently shaken and deformed, aggravating structural damage. Shaking of buildings, bridges, and other structures resulted in crippling damage and sometimes complete destruction.

The 500-mile-long disaster region extends from north of Concepción to south of the island of Chiloé (the large island on which Ancud is located, shown at the lower left in Fig. 1); in this area about 4000 people were killed and damage estimated at $400 million was sustained. This area contains 2.5 million people, and the Chilean government reports that 450,000 of their homes were damaged, 10 percent of them beyond repair. The tsunami which was responsible for most of the deaths in Chile caused additional loss of life and property in Hawaii and Japan. The toll in Japan was 180 dead and $50 million property damage.

While workers in the scientific aspects of seismology receive new earthquake data constantly, engineers must rely on experience with and motion records of the relatively infrequent destructive earthquakes. It appeared from preliminary reports that here was perhaps the largest earthquake to afflict a heavily populated area since the earthquakes of San Francisco in 1906 and Tokyo in 1923. Because of the implications for earthquake-resistive design of structures, it was clear that an inspection and gathering of facts should be undertaken by United States engineers. Accordingly, the Earthquake Engineering Research Institute, an organization of engineers and seismologists who donate their time to the institute's program of advancing earthquake safety, established a team to visit the afflicted area. The National Science Foundation made funds available for travel and for preparation of reports. The team members were Karl V. Steinbrugge of the Pacific Fire Rating Bureau, Ray W. Clough of the University of California at Berkeley, and myself. Kiyoshi Kanai of the Earthquake Research Institute, Tokyo University, accompanied the team, which spent two weeks in Chile during June 1960. A very large number of Chilean individuals and institutions graciously made available their knowledge and their assistance. At the time of writing, plans are being made for the preparation of an appropriate report.

The Principal Shock

The first large shock, of magnitude 7.5 on the Richter scale, occurred on 21 May 1960, at 10:03 Greenwich Civil Time. It was centered near the coast line in the vicinity of Concepción. The principal shock, of magnitude approximately 8.5, occurred on 22 May at 19:11 GCT and was centered near the coast line at about the latitude of Puerto Montt. Both of these locations are highly tentative. It has been inferred from observations of damage and from findings on Chilean earthquakes in the past that the disturbances occurred at depths of around 50 kilometers. This and other scientific factors are being currently studied with a view to refinement and correlation. Several earthquakes of magnitude 7.5 to 8 occurred among the hundreds of aftershocks, a shock of about magnitude 7 having been released as recently as 14 August. The magnitude rating is an index of the amount of energy released; magnitude 8 corresponds to an energy release about 60 times that of magnitude 7. For comparison with destructive earthquakes in California it may be noted that at San Francisco in 1906 the magnitude was 8.3; at Long Beach in 1933 it was 6.3; in Kern County in 1952 it was 7.6. However, California earthquakes generally have been at considerably shallower depths (around 18 kilometers) than the 50 kilometers inferred for the recent Chilean earthquakes.

The effects of the May 1960 earthquakes may be outlined with the aid of Fig. 1, a map of south-central Chile. Damage due to the first large shock was limited to the Concepción region, though the shock was felt throughout the area of the map and, fortunately, was taken by the people of Chile as a warning. Most of the geodynamic effects, damage, and loss of life were associated with the principal shock on 22 May. The tsunami thus generated invaded the coastal towns and villages marked on the map with the symbol *T* and swept across the Pacific to

The author is professor of engineering at the University of California, Los Angeles.

wreak havoc on the coasts of Hawaii and Japan and, in lesser degree, in California. A tectonic subsidence of 1.6 meters occurred in the Valdivia region. A lava flow erupted from a new vent in the side of Mount Puyehue. Disastrous damage due to shaking occurred at the cities of Valdivia and Puerto Montt, and at a number of smaller communities. Concepción and the surrounding area sustained heavy damage. The consensus among observers is that the heaviest shaking occurred along the coast and along the north-south chain of lakes and volcanoes, with much less shaking in the long central valley between. Most interesting of the hundreds of landslides were the three which dammed the San Pedro River downstream from Lake Riñihue.

In due time, as a result of full analysis of damage reports, it will be possible to construct an isoseismal map. Such a map will show, on the Modified Mercalli Scale of 1931, the *intensity*, or severity of shaking, at each place in the afflicted area. A given earthquake has one *magnitude*—for example, 8.5 in the principal Chile earthquake—but it has a whole distribution of intensities. Preliminary estimates of intensity for the Chilean earthquakes are VIII at Concepción, X at Valdivia, XI at Puerto Montt, and VII to VIII at Osorno in the central valley. By comparison, the maximum intensities were X at San Francisco in 1906 and VIII at Bakersfield in 1952. Construction of the isoseismal map for Chile will not be simple, for the several shocks had overlapping effects. Such maps are very useful, when accumulated over a long period of time, both for estimating earthquake risk and for studying intensity and its anomalies as a function of magnitude, hypocentral depth, and geology.

Fig. 1. May 1960 earthquake area. *T*, towns and villages invaded by tsunami.

Seismic Records

Typical of seismograms obtained throughout the world is that of Fig. 2, which is a portion of the record obtained for the principal Chilean shock at the California Institute of Technology campus in Pasadena with a Wood-Anderson seismometer. At this great distance the earth responded in characteristic fashion, the surface waves exhibiting a 20-second period. Figure 3 illustrates another type of record—a type which, unfortunately, could not be obtained in this earthquake. The example shown is a United States Coast and Geodetic Survey strong-motion accelerograph record from the 1952 Kern County earthquake. Data from this special instrument and from the many similar ones in California and Japan are of fundamental value in earthquake engineering, as they show approximately how the ground moves in earthquakes which are strong enough to

damage structures and to render the usual sensitive seismographs inoperable. On the basis of many such records obtained in the past 30 years in the United States, important strides are being made in earthquake-resistive structural design. It is of great importance, however, to obtain strong motion records for all seismically active regions in the world.

The hypothetical mechanism of generation of the May 1960 tsunami is a subsidence of the sea bottom along an off-shore fault trace paralleling the coast. Such a fault is believed to be associated with the principal shock and with the tectonic subsidence around Valdivia. Clear evidence of surface fault movement has not been found to date on land. The heights of tsunami waves were 9 meters at Corral, 8 meters at Puerto Saavedra and Ancud, 5 meters at Hilo, Hawaii, and from 1.2 to 4.2 meters along the Pacific coast of Japan. In both Chile and Japan some of the small coastal villages were literally swept out to sea. There was loss of life at Hilo and in Japan in spite of the successful operation of the tsunami warning instruments in the Pacific. The tsunami is being investigated and reported by others, and I will not consider it further here except to note that much of engineering and scientific value is being learned.

To make the discussion of structural damage more meaningful, I will make some brief comments on the nature of earthquake motions and the manner in which structures resist them. Strong instrumental records such as that shown in Fig. 3, together with observations of damage, reveal that the horizontal components of motion are the most injurious. This is partly because the horizontal motions are more severe than the vertical, and partly because structures usually are moderately well designed for vertical load in order that they may carry their own weight plus the weight of their contents. But since large horizontal forces act on structures only occasionally—forces due to high winds or to earthquakes, for example—they are difficult to comprehend and evaluate and are frequently underestimated or neglected. Elementary practice in earthquake-resistive design of simple structures calls for providing strength to withstand a horizontal force of around 15 percent of the weight of the structure and its contents. All parts and all joints must be able to contribute

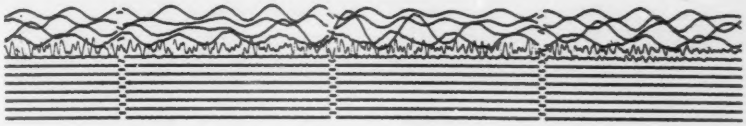

Fig. 2. Portion of a seismogram of horizontal ground displacement during the 22 May 1960 main shock in Chile, recorded at the Pasadena campus of the California Institute of Technology. The instrument was a standard Wood-Anderson seismograph with period 0.8 second and magnification 2800 on the original record. Time marks shown are at 1-minute intervals. [G. W. Housner]

appropriately to withstanding this force. In addition, the various parts of the structure which must vibrate together are securely tied together and, in turn, tied to the foundation, which must have the capacity safely to transfer the horizontal force into the ground. Careful attention is also given to the quality of the ground itself. In more complex structures, such as bridges, tall buildings, or dams, a much more sophisticated approach is necessary.

Soil Failure

Deformation and failure of the soil in the Chilean earthquakes were dramatically manifested in many ways—in landslides, slumping and fissuring of soft ground, and failures of foundations and earth structures. The afflicted area is a glaciated region, and the soil types in the heavily damaged zones reflect this geologic history. Three examples follow. The landslides below Lake Riñihue occurred in glaciofluvial deposits that were saturated because of the heavy autumn rains of that region. The soil, of predominantly fine sand, apparently flowed as a liquid under the influence of the vibration. These slides, of which the largest covered about 1 mile along the San Pedro River, raised the level of Lake Riñihue by 15 meters, submerging the town of Riñihue and threatening Valdivia, 50 kilometers downstream, with floods. As a result of earth-moving operations reminiscent of those on the Madison River in Montana after the 1959 earthquake, the danger of sudden erosion of the slides appears at this writing to have been alleviated. Figure 4 shows one of the smaller of the slides. This same situation occurred previously at Riñihue in an earthquake in the year 1575.

Liquefaction of loose, fine sandy soil seemed again to be the failure mechanism in the cases of the new highway (Fig. 5) between Puerto Varas and Puerto Montt and of the quay wall (Fig. 6) at Puerto Montt harbor. The strength of sandy soil is derived principally from shear resistance due to internal friction, which is proportional to the compressive forces between adjacent soil particles. The compressive forces are due to the weight of the soil. Under intense vibration of a water-saturated loose sand, part of this compressive force is transferred to the water, which has essentially no shear strength, and this results in marked weakening of the soil. The complete

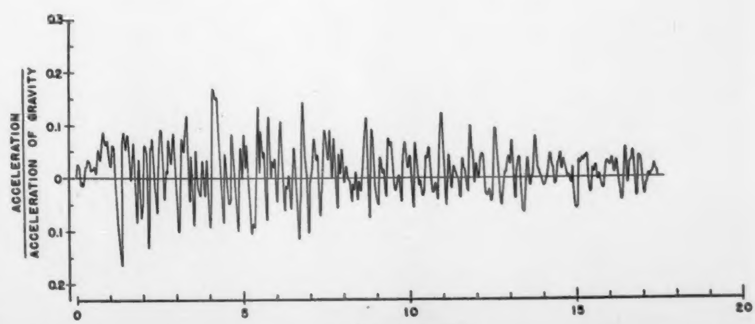

Fig. 3. Typical strong-motion acceleration seismogram of horizontal ground motion at Taft, California, on 21 July 1952. The U.S. Coast and Geodetic Survey accelerographs record one vertical and two horizontal components.

collapse of the highway fill appeared to be due to these characteristics in the fill itself, but the underlying swampy ground doubtless contributed to the difficulty. The catastrophe at the harbor, of which Fig. 6 is merely illustrative, is hard to explain except in terms of this mechanism. Differential settlements and horizontal foundation movements of the order of feet, occurring along the downtown water front of Puerto Montt and at the nearby naval base (Figs. 7 and 8), are associated with the same kind of soil.

Through their joint efforts, the Chilean Institute of Geologic Investigation and the U.S. Geological Survey are demonstrating a direct relationship in Valdivia and Puerto Montt between local soil conditions and damage to the indigenous wood-frame houses. As has been found elsewhere in many previous earthquakes, such houses on soft, marshy, or loose soil, especially if these soils are deep, are much more generally and severely damaged than those on the firmer, usually higher, ground.

Structural Damage

Damage to railway and highway bridges was widespread. This, coupled with many failures of highway and railroad embankments, landsliding, and land submergence due to subsidence around Valdivia, effectively cut off land transportation in southern Chile. A rough survey suggests that most of the bridge damage was due to abutment failures. For example, at the Isla Tejas bridge in Valdivia both end spans were badly damaged, and the piers on both ends tipped toward the banks, because the river banks at both abutments slid toward the river. The same phenomena occurred at a second bridge in Valdivia of the same design. The railroad bridge at Llanquihue had a 4-foot longitudinal displacement relative to its abutment. Many bridges seen by the team exhibited this kind of damage resulting from abutment failure. In other cases deck spans dropped because of the movement of piers. At the Bio Bio River bridge in Concepción, four piers tipped over completely, breaking off from their pile foundations and falling in the plane of the bridge axis. At a bridge 20 kilometers north of Valdivia, deck spans fell because of the rotation of piers which resulted from an abutment's sliding toward the river.

Houses in the northern part of the damage area were predominantly of crude masonry and adobe. The disintegration so familiar to students of earthquakes was the usual failure mechanism. To the south, most houses were built of wood, and the failure of the walls to resist the lateral forces resulted in many collapses and in many instances where the walls tipped from 5 to 20 degrees, leaving floor and roof relatively horizontal. Very common in the case of the frame houses was the tipping over of the foundation walls or piers or the horizontal sliding of the house off its foundation. Fortunately, very few fires broke out in connection with the earthquakes, and those few were confined to single buildings. Figure 9 shows the collapse of a composite

Fig. 4. One of the smaller landslides on the San Pedro River below Lake Riñihue.

Fig. 5 (left). Failed highway fill between Puerto Varas and Puerto Montt. Fig. 6 (right). Failed gravity quay wall at Puerto Montt harbor.

Fig. 7 (left). Settlement at the naval base, Puerto Montt. Fig. 8 (right). Relative horizontal movement of two parts of a building near the naval base, Puerto Montt.

Fig. 9 (left). Collapse of a composite wood-frame and adobe building in Valdivia. Fig. 10 (right). Failure of the supporting members of an elevated water tank in Rio Negro.

adobe and wood-frame building in Valdivia.

A large number of reinforced-concrete elevated water tanks were damaged. Figure 10, a tank in Rio Negro, shows the characteristic pattern of shear failure of horizontal members and bending failure of columns. These tanks were constructed after a design, originating in Germany, which apparently did not provide for the transmission by the supporting members of the horizontal seismic forces between the heavy tank and the ground.

Chile had had a catastrophic earthquake in 1939, in the Concepción region, in which 30,000 people were killed. As a result of that experience, a new building code was put into effect, and major buildings erected since that time have been subject to a design requirement that takes earthquake loading into account. Thus, it was not surprising that the post-1939 construction behaved markedly better on the average than the older buildings. This was particularly noticeable in Concepción, where, though some of the newer large buildings were damaged, the damage to the older structures was much more pronounced. Errors in design or construction, or lack of knowledge about the behavior of soils and foundations in earthquakes, were the causes of most damage to the newer large buildings throughout the afflicted area.

Two examples of damage to modern buildings, from among the cases where soil conditions were not the dominant feature, are illustrative. The first of these buildings is of reinforced concrete, and the second of steel-frame construction, though in fact there were relatively very few steel-frame buildings in the afflicted area. The reinforced-concrete building is a seminary consisting of a three-story and a four-story wing resting on firm high ground in Puerto Montt. The columns proved unable to transfer the horizontal force down to the ground, and many of the columns, especially in the second stories of both wings, were completely shattered, as were many of the masonry partition walls. It appeared that the concrete was of substandard quality. The steel-frame building is a three-story chemistry laboratory at the University of Concepción, on a rigid concrete raft footing resting on deep, soft alluvium. The open first floor contained a number of steel diagonal members with welded joints connecting bottoms of columns with second-floor girders in both longitudinal and transverse directions. The welded joints failed early in the first large shock, but the building was able to ride out the violence of this and the subsequent earthquakes without collapse. There are important lessons to be learned from these and many of the other damaged as well as undamaged modern buildings. The learning of these lessons will require detailed analyses based on the original structural designs.

Conclusion

Both the scientific and the engineering aspects of our knowledge of earthquakes will be significantly augmented as a result of the reports now being prepared by investigators from Chile, Mexico, Japan, and the United States. The wisdom of making full reports and analyses was demonstrated from the comprehensive treatments published after the great earthquakes in San Francisco (1906) and Tokyo (1923); on the basis of those reports and analyses, technical papers are still being written today. Engineers stand to gain valuable information on the suitability of modern antiseismic design methods and criteria, on the currently emerging concepts of dynamic design and limit design, on soil behavior and the action of foundations and earth structures, on characteristics of tsunamis, and on tsunami warning systems. Scientific study of volcanoes, tsunamis, tectonic movements, faulting, earthquake mechanisms, and the character of the earth will be aided. The people of Chile, who are moving with energy and purpose toward reconstruction, may find some comfort in knowing that the world is learning from their tragedy.

Scientific Progress and the Federal Government

The Panel on Basic Research and Graduate Education of the President's Science Advisory Committee reports.

This paper is a brief statement on a large set of problems: the problems which center on the advancement of science by basic research and the making of scientists by graduate education. This is only one part of the complex world of modern American science, but it is a critically important one. We have tried to state clearly the fundamental character of the environment which is required for scientific progress and for the making of good young scientists. We then consider the way in which these requirements should affect the policies of both the federal government and the universities, which are today the two forces in our society whose actions most affect the health and strength of basic research and the training of scientists.

We find much, both in the government and in the academic community, which needs improvement, but we have made no attempt to prescribe detailed policies for either party. The last 20 years have seen a remarkable growth of support of many kinds for basic research and graduate education, and the role of the federal government has, on balance, been highly constructive. On the whole, our universities are much stronger today in science than they were a generation ago. We have great confidence that energetic leadership and constant effort can find good answers to the practical problems of the future. A short statement like this may hope to contribute, not specific solutions, but rather some general ideas about the nature of the task and the principles that should guide us in working on it.

Background

Both the security and the general welfare of the American people urgently require continued, rapid, and sustained growth in the strength of American science. Other reports of qualified bodies, and earlier reports of this committee (*1*), have argued in detail the reasons which make this growth vital to us all. We believe that most Americans are in favor of more and better science. In a general way Americans recognize that scientific understanding is at once highly valuable in its own right and quite indispensable for the sustained progress of a modern industrialized society. We are proud of our great accomplishments, and we become concerned whenever it appears that our scientific effort in any field may be second best. Most of all we have learned to recognize that the defense and advancement of freedom require excellence in science and in technology.

But our acceptance of these quite modern ideas does not mean that we understand fully their consequences for our policy and practice. American science in the next generation must, quite literally, double and redouble in size and strength. This means more scientists, better trained, with finer facilities. Many forces contribute to this urgent need for growth. Our population is rapidly increasing, so that there are more and more young people to be taught, and we have nothing like the number of qualified teachers we need, even now. Science itself is expanding so fast that our efforts would have to be much increased if we were only to keep up with its general international momentum. The training of scientists takes longer than it used to, and the facilities needed in a modern laboratory are usually much more complex and expensive than those that were needed only a few years ago. Science and technology today have a steadily growing, mutual impact, so that the practical man has need of the closest and most immediate access to new results in basic science. Thus, both science and scientists must be more and more widely diffused throughout our society. We need more men doing more things, with more support, in more places. And each of these requirements is better measured by multiplication than by addition. It is the simple truth that if this country is to safeguard its freedom and harvest the great opportunities of the next generation of

Glenn T. Seaborg, chairman of the Panel on Basic Research and Graduate Education of the President's Science Advisory Committee.

science, the level of its scientific investment must be multiplied and multiplied again.

Yet the right word is *investment*. What this country spends on excellence in the sciences is not money gone with the wind. It is money that brings us handsome returns, and of many kinds. In immediate economic terms the proposition is clear enough: what we have done in science has brought our society riches many times greater than what science costs us, and this will be true as far in the future as we can see. In economic terms, indeed, scientific investment has quite extraordinary power. Ordinary capital investment puts savings to work on labor-saving machinery that is already known and understood; the increased wealth produced is what separates the developed modern society from helpless poverty. But scientific and technological investments are still more powerful tools, since they invest in the discovery of what we do not yet understand. We are only just at the beginning of the use of scientific investment in this large sense, and the returns it can bring in are literally incalculable. Simply in terms of economic self-interest our proper course is to increase our investment in science just as fast as we can, to a limit not yet in sight.

But we should not emphasize only the material returns of scientific investment. Science yields a return also in the quality and humanity of our civilization. Science is not merely an inducement to progress, it is an affirmation of man's respect for nature and a way to the fulfillment of some of his highest capacities. Science is enriching, but at its best it is much more—it is enlarging to the spirit. This higher value is one we should never leave out of account in our desire to reassure ourselves that science "pays." Indeed, any shortsighted calculation of return on investment is likely to be self-defeating. Scientific progress does not occur in any neatly predictable way; nor can we be sure ahead of time which research project is likely to have particular consequences for our prosperity or security. Moreover, scientific discovery is not easy, and many experiments fail. Nothing could be more unwise than an effort to assign priorities or judge results in basic research on any narrow basis of immediate gain. It is the advance of science as a whole on which we must rely, for material as well as other returns.

Much of this basic argument for the strengthening of American science applies equally to other fields of learning. While this report centers on the needs of science, we repudiate emphatically any notion that scientific research and scientific education are the only kinds of learning that matter to America. The responsibility of this committee is limited to scientific matters, but obviously a high civilization must not limit its efforts to science alone. Even in the interests of science itself it is essential to give full value and support to the other great branches of man's artistic, literary, and scholarly activity. The advancement of science must not be accomplished by the impoverishment of anything else, and the life of the mind in our society has needs which are not limited by the particular

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Members of the panel are as follows: Glenn T. Seaborg, chancellor of the University of California, Berkeley, *chairman*; William O. Baker, vice president for research, Bell Telephone Laboratories; George W. Beadle, chairman of the Division of Biology, California Institute of Technology; Henry E. Bent, dean of the Graduate School, University of Missouri; McGeorge Bundy, dean of the Faculty of Arts and Sciences, Harvard University; William B. Fretter, professor of physics, University of California; Caryl P. Haskins, president, Carnegie Institution of Washington; Emanuel R. Piore, vice president for research and engineering, International Business Machines Corporation; Roger Revelle, director, Scripps Institution of Oceanography, University of California; Frederick E. Terman, vice president and provost, Stanford University; Alan T. Waterman, director of the National Science Foundation; Alvin M. Weinberg, director of Oak Ridge National Laboratory; John E. Willard, dean of the Graduate School, University of Wisconsin; and O. Meredith Wilson, president of the University of Minnesota.

concerns which belong to this committee and this report.

We do not, in this report, attempt to consider what direct responsibility and interest the government has for strengthening basic research and graduate education outside the sciences. This is a subject which deserves careful attention, but it is beyond our mission. What we can say, however, is what earlier reports of this committee have regularly emphasized, that neither the government nor the universities should conduct the support of scientific work in such a way as to weaken the capacity of American education to meet its responsibilities in other areas. The costs of scientific progress must not be paid by diverting resources from other great fields of study which have their own urgent need for growth.

Basic Research and Graduate Education

Science is a large field, and in this report we want to concentrate attention on two parts of it: the part in which research is pursued with the purpose of advancing scientific understanding, and the part in which young college graduates are helped to become scientists. Our shorthand terms for these two activities are "basic research" and "graduate education."

Basic research is the cutting of paths through the unknown. As most of us know today, it is the pacesetter for technology and the raw material of invention. Its growth can be assisted, and its general value can be confidently asserted, but it depends, in the end, on the imaginative powers and scientific skills of the men who do it. Basic research is as hard as it is exciting, and while it contributes enormously to the national welfare, what usually moves the scientist is not so much this practical consequence of his labor as the simple but powerful urge to know how nature works. A free society can honor the scientist's curiosity without forgetting his social value.

Because basic research is aimed at understanding rather than at practical results, the layman sometimes assumes that it is entirely abstract and theoretical, and that only when it becomes a matter of industrial development does it "come down to earth." This is a false notion, and its falsity becomes increasingly clear with time. Indeed, one striking characteristic of our scientific age has been the disappearance of the barriers between pure and applied science. Not only are we finding important technological applications for mathematical and scientific knowledge which was formerly thought of as abstract and "useless," but the advance of technology has both generated new problems in pure science and provided new tools with which such science can be advanced more effectively. The development of the techniques and hardware for radar during the war, for example, gave the physicist and the chemist a new and refined tool for investigating the properties of solids and of chemical compounds. Conversely, the extensive use of this tool in basic science has opened the way to entirely new techniques in electronics. Similarly, the development of large-scale electronic computers has led engineers to find practical uses for some of the most abstruse and "impractical" branches of higher mathematics, while the understanding of the techniques of using computers has, on the other hand, given us deeper insight into some aspects of the behavior of complex biological and social systems. Basic and applied science today are distinguished less by method and content than by motivation. Part of the strength of American science stems from close intellectual intercourse between basic and applied scientists. Very often, indeed, the same man can be both "pure scientist" and "engineer," as he works on different problems or on different parts of one problem. We do not believe in any artificial separation between basic and applied research or between science and engineering. The fact that a scientific advance is useful does not make it unscientific.

Graduate education for scientists is usually seen as what comes after the B.A. and before the Ph.D. For us it is this, but also more, and in our view any definition in terms of an interval between two degrees obscures much more than it clarifies. We are using the term here to mean that part of education which seeks to turn a young man or woman into a scientist. By the word *scientist* we mean someone who is fit to take part in basic research, to learn without a teacher, to discover and attack significant problems not yet solved, to show the nature of this process to others—someone, in short, who is equipped to spend a lifetime in the advancement of science, to the best of his ability.

It is a fundamental contention of this report that the process of graduate education and the process of basic research *belong together* at every possible level. We believe that the two kinds of activity reinforce each other in a great variety of ways, and that each is weakened when carried on without the other. We think also that this proposition has substantial implications for the policy of both the federal government and the universities. Because the proposition is so central to our argument, we must try to demonstrate it thoroughly.

In one sense, it is almost self-evident. If graduate education aims at making scientists, and if inquiry into what is unknown is the moving principle of all science, it is not surprising that experience of this kind of inquiry should be essential in graduate education. Clearly, such experience is best obtained in association with others who have had it or are having it themselves. The apprentice scientist learns best when he learns in an atmosphere of active research work. It is true that only a minority of those who receive a Ph.D. in science continue their subsequent careers in basic research. The majority go on to applied research in industry or to teaching in college, where research opportunities are limited. (Even in the universities many scientists are not active in research.) Nevertheless, such experience as all graduate students should have with basic research is highly important. In all forms of scientific work a man's effectiveness is multiplied when he has that depth of understanding of his subject that comes only with the experience of working at a research problem.

But if all this is so, it does not seem to be fully recognized in the standard practices of most universities and federal agencies. For as we are describing it, the process of graduate education depends on "research" just as much as upon "teaching"—indeed, the two are essentially inseparable—and there is a radical error in trying to think of them as different or opposite forms of activity. From the point of view of the graduate student, the teaching and the research of his professor are, at the crucial point which defines the whole, united. What he learns is not opposite from research; it *is* research. Of course many necessary parts of a scientist's education have little to do with research, and obviously, also, for many professors there must be a gap between

teaching a standard graduate course and working at one's own problems. Moreover, many good teachers—men who keep up with the new work in their subject and communicate its meaning clearly to their students—are not themselves engaged in research. Yet we insist on the central point: the would-be scientist must learn what it is like to do science, and this, which is research, is the most important thing he can be "taught."

So far we have been arguing that graduate education requires the experience of basic research. What happens when we turn the matter around, and ask whether basic research must be carried on only in conjunction with graduate education? Here the answer cannot be so categorical. Though our general conviction is that a fundamentally reciprocal relation does exist, it is clear that research of outstanding quality is often carried on in isolation from teaching and indeed quite outside the universities. While the great teacher of graduate students is almost invariably a research man too, there are many notable scientists who have as little as possible to do with teaching. First-rate industrial and governmental laboratories with commitments to specific programs are necessarily separated in some measure from teaching of a conventional sort. Thus, basic research can be, and is, carried on without much connection to graduate education.

Yet in the long run it is dangerous to separate research in any field entirely from education. If a research field is to be attractive to good young men, it ordinarily needs roots in the universities. The pool of graduate students in our universities is the pool from which the scientists of the future must come. These young people do not easily study what is not taught; they do not often learn the meaning of research which does not exist in their environment. A scientific field which has no research life in the universities is at a grave disadvantage in recruiting new members. As learning and teaching require research, so research, in the end, cannot be sustained without teaching. Hence it is always important for research installations to maintain effective connections with students. In a later section we note some of the consequences of this rule for both the government and the universities.

Meanwhile it is worth noting that the practical need for connection between a research installation and the source of scientists is not the only reason for doubting the value of any sharp separation between research and teaching. There is also the fact that in the wider sense all first-rate research laboratories are permeated by an atmosphere of learning. Successful research can be defined, indeed, as learning what has not been taught before, and a good scientist is constantly learning from others as a part of his campaign to find out something on his own. It is not an accident, therefore, that in any outstanding industrial or governmental laboratory the atmosphere is reminiscent of the university. In such laboratories, moreover, the scientist's concern with "research for its own sake" is often very strong; much excellent basic work is done in such laboratories, in support of general programs of applied research (*2*). We believe that research, learning, and teaching are deeply connected processes which should be kept together wherever possible. Not all basic research should be —or could be—performed in our universities, but where it is done separately, special efforts should be made to take advantage of its educational value.

Role of the Federal Government

Basic research and graduate education, together, are the knotted core of American science, and they will grow stronger together or not at all. Let us now consider the consequences of this principle, first for the government and then for the universities. The federal government, by its varied missions and the size of its financial commitments, is the most powerful single force in this whole field, while the universities are the natural holders and custodians of the knotted core. Both have done much to strengthen, and something to weaken, the common enterprise in recent decades. Both must do better in the years ahead.

The federal government, through many agencies, is now by far the most important source of funds for research in the universities. In 1957–58 the federal share in all such research was about 70 percent. This astonishing expansion in federal activity is the product of several forces, all of them initially related to specific needs of specific branches of the government. The two most important purposes of the government in supporting research have been defense and health; more than three-fourths of all federal funds for such research in 1959 came from agencies with one or the other of these two missions.

The government's first interest in its relations with universities was to obtain the practical advantages of research. Historically, the earliest large-scale relations were those in the field of agriculture, which connected the government to the land-grant institutions. Then, during World War II, American science conclusively demonstrated its practical value, and in the years after the war, first the defense agencies and then those related to health developed large-scale research relations with the universities. At first these relations were based on contracts allowing compensation for services rendered. Government contracts have supported a great deal of research of high quality; they have, for example, paid for almost all of our remarkable postwar effort in nuclear physics. Nor has this support been limited narrowly to the fields with high practical significance or political appeal.

Yet in its essence the concept of "purchase of services," which is implied in any government contract, was and is a doubtful one when applied to basic research. Basic research, almost by definition, has no clearly predictable practical result, and so the Congress and the federal agencies involved have had to interpret very broadly the notion of "value received" in return for sums spent on research contracts. But conversely, the support of university research has been hampered by contract rules which strictly limit the ways in which universities can be compensated for their costs. The whole framework is somewhat arbitrary and unrealistic. The wonder is that it works as well as it does.

From the point of view of this report, a particularly grave difficulty in the support of research by government contracts is that by its very nature support given through such a mechanism tends to separate research from education. In the research contract the one recognized "product" is "research"; yet if the government has an interest in basic research in any given field, it inevitably has a related interest in graduate education in the same field. Thus, the government is almost forced to work against its own interest as well as that of the university when it uses an instrument whose formal concern is

with research results alone. It is greatly to the credit of many able public servants that this inherent difficulty has often been overcome by imaginative and farsighted administration. Many graduate students have been helped by contract funds in a fashion that is both constructive and proper. But the research contract, with its concept of services purchased, remains an imperfect instrument. Even for the advancement of basic research as such it is awkward, because first-class research is really not a service to be contracted for. And for larger purposes it is wholly inadequate.

All government agencies are now empowered to use grants instead of contracts in supporting basic research; the National Science Foundation and the National Institutes of Health, particularly, have used this form extensively for some years. The use of grants sometimes has the regrettable consequence of failing to provide for the full cost of the research that is supported, and sometimes the complexities of application and processing for even a small project grant compare unfavorably with the best practice of contracting agencies. But on balance and in the long run, the grant is a better instrument than the contract—it is more consistent with the nature of basic research.

Grants and contracts are both used to support specific research projects. This is good, in and of itself—especially when such support is provided, as it often is, with a minimum of red tape and for broad objectives, with relatively long time schedules (three-year terms were recommended in an earlier report). Support of good men or groups in specific projects can be particularly effective in ensuring that excellent scientists and excellent problems are identified wherever they may be. While the process of evaluation and award is time-consuming both for government officials and for outside scientists who serve on advisory panels, it is well done, on the whole. But project support, in and of itself, does not fully meet the needs of the federal government.

We can understand this matter better if we consider for a moment the federal government's larger purposes in relation to basic research and graduate education. In addition to the research interests of particular agencies, the government has two other, more general, responsibilities. One is its concern for the development of fields of basic and applied science which may be of general importance for the national security and the general welfare; the other is its concern for the strength of American science and higher education as a whole.

There are many fields of science in which the United States could well become stronger and more active, both from the point of view of the national defense and from that of the public welfare. It is unfortunately not true that scientists always and automatically sort themselves out into the most relevant and productive fields of work. Science, like any other human activity, is subject to the distortion of human frailty, and scientific fashion is not always sound. Moreover, even when individual scientists spot promising untilled fields (and it is scientists who do spot them), it is often hard to find funds and facilities for the new undertaking from within hard-pressed universities.

We think it plain that the federal government should act in such areas of scientific promise. No other agency in our society is responsible for the national security, and a large field full of new problems, such as space science or materials research, is potentially vital to our safety. No other agency in our society is responsible for the general welfare, and all major fields without exception can be expected to contribute to the general welfare. No other agency, finally, has the financial strength to provide the necessary support—and incentive—for work in expensive new undertakings. It can be said without qualification that our society will be endangered and impoverished if these things are not done, and that only the federal government can take the leadership to get them done. We do not mean, again, that only federal action will be needed; we do mean that it must play a large initiating and sustaining role.

When we construe the matter in this way, it becomes clear that no narrow or single-instrument method of action will serve the government's purposes. For example, if oceanography is urgently important (as it is), if good oceanographers are scarce (as they are), and if oceanographic facilities—especially modern sea-going vessels—are almost nonexistent (as is also the case), the federal government cannot discharge its responsibilities by signing a research contract with any one institution. It has to look at the whole subject and all its needs. It may be more important to buy some university a ship—as the National Science Foundation has recently done—than to execute a research contract for work under one of its professors. It may also be important to offer fellowships or to assist in the initial expense of a new set of courses. The government will not be able to serve its own interest if it cannot put its money freely wherever it sees an urgent need.

In speaking of new fields of need and opportunity, we are seeking to emphasize the things that now need doing. We could also call attention to the many things that have already been done, above and beyond the standard research contract. The federal government has, of course, already built major research facilities when no one else could—most notably in the field of nuclear physics. It has also begun to make grants for research facilities as well as for research—most notably in the field of health. The National Science Foundation, with the broadest charter of any agency in the field, has granted fellowships both directly to students and indirectly through universities, and recently it has planned to make unrestricted research grants to institutions receiving funds on a project basis from its hands. Nor should we neglect the imaginative use of training grants in medicine and health, the fellowship program of the Atomic Energy Commission, or the special help made possible by the National Defense Education Act. Still, all of these are limited *ad hoc* programs which only partially meet the government's own interest in graduate education and basic research; we have hoped, by discussing a new topic like oceanography, to show how general and unlimited that interest can be.

The government has one still greater interest in these matters. It is, quite simply, that university science should be as strong as possible. This blunt statement does not arise from sentimental affection, or from professional affiliation, though most of us must confess to both. It is rather that the function of the universities is one of absolutely critical importance to the national welfare. As our scientific efforts have expanded in many industries and government installations, the universities have naturally lost their near monopoly on scientific work. But it is essential that this process should not

go too far. For the universities are the source of tomorrow's scientists, as they are the natural centers for jointly thriving basic research and graduate education.

Obviously this proposition has meaning for many others besides the federal government. The universities themselves are not without resources, and they have a particular and urgent obligation to spread the word of their high mission wherever they have friends who can help. State governments, graduates, generous private citizens, and foundations all have a part to play in strengthening the American university. Moreover, as we shall presently see, the American university has a special opportunity and obligation to see to it that its responsibility for judgment and leadership in basic research and graduate education is well discharged.

But when all these things have been said, the first and greatest of responsibilities comes back to the federal government. No matter how many diverse elements of our society may join in their support (and the more the better), basic research and graduate education are in the end, by their very nature, a problem for the nation as a whole, and so for the national government. There is not one physics for California and another for Texas. A first-rate program in Massachusetts or Connecticut must not be limited to New Englanders. Science flourishes by honorable rivalry, but not by any effort to consider only narrow or local interests. Both basic research and graduate education must be supported in terms of the welfare of society as a whole. It is in this large sense that the role of the federal government is inevitably central.

The truth is as simple as it is important: Whether the quantity and quality of basic research and graduate education in the United States will be adequate or inadequate depends primarily upon the government of the United States. From this responsibility the federal government has no escape. Either it will find the policies—and the resources—which permit our universities to flourish and their duties to be adequately discharged, or no one will.

It is much easier to state this general interest of the federal government than it is to delineate its consequences. Indeed, in the largest sense the consequences are too many for numbering, because in essence this general proposition should color every action of every federal agency in all its dealing with our universities. With all their irritating faults, universities are essential agencies of our national hopes, and they must be treated accordingly.

The Job of the Universities

American universities are far from perfect, and their best spokesmen are the first to admit it. In a sense they do not have the excuse of government, which has entered the field only recently; their very reason for being is that they should support the high purposes we are concerned with here. Basic research and graduate education—as we have said and as all will easily agree—are of the very essence of the fundamental purposes of the American university. Yet many do much too little, and none does all it should, in these great areas.

In the first place, it is often as hard for the university as for the government to keep it clearly in mind that *basic research and scientific education* go together. The first and simplest temptation, we fear, is the neglect of research. Most American universities have their origin in a public need for education—for instruction, for teaching—and in most of them there is still maintained the same artificial and fundamentally wrong division between research and teaching that bedevils the government's relations with universities. But while the government finds it easier to pay for research than for teaching, the university, too often, budgets for teaching as a matter of course, and for research only when special circumstances permit. The result is that in all but a few American universities the standard teaching assignment of the professors (significantly called his "teaching load") is such as to make it difficult for him to carry on any serious program of investigation of his own.

On the other hand, the university itself sometimes allows favored individuals to play no teaching role whatever, as a means perhaps of attracting and keeping men of particularly outstanding reputation. The danger in such a practice is obvious, since it appears to suggest that the very best men deserve exemption from teaching. While in any individual case such an arrangement may be justified, it is of the first importance that universities, and scientists themselves, should sustain the value of teaching as well as research. This is not a rigid matter of splitting every man's time in equal but separate parts. In the best departments there will be men whose time is spent mainly on research and men who are mainly teachers, and it is foolish to hold any individual to any arbitrary standard that cramps his style. What is essential is that the environment as a whole should be an environment of learning, investigation, and teaching—all together. Only too often the universities fail to understand and support this image of their nature.

More broadly, our universities have been slow in finding effective ways of encouraging scientific research and training at all the new levels and in all the new ways which the age of science makes possible. Graduate education is not as good as it should be. Outmoded rules of study too often impede the student's access to the experience of modern science. Research programs are too often kept in isolation from the mainstream of student life. Special research installations are too often not imaginatively used as a source of learning and teaching. New fields of study are ignored because they inconveniently cross departmental barriers. Strong understanding of the meaning of the age of science is too rarely found among university administrators. The universities themselves have much to do.

Perhaps the most important single task of the universities is to see to it that their own standards of freedom and excellence are maintained in a period of growing connection with government. While we do not share the notion that government money is necessarily subversive of university freedoms, it is obvious that large-scale federal spending, like any other form of patronage, has its hazards. In the record of the last 15 years there is much more ground for hope than for fear, but occasionally government action has distorted the direction of research or unwisely discriminated against particular scientists on irrelevant grounds. It is to the credit of the government that such cases have been the exception, not the rule, and we commend the good sense which has led the Administration to oppose discriminatory and useless affidavits of disbelief as a condition for fellowship aid.

But the first and greatest responsibility for keeping our universities free and self-reliant rests with the universi-

ties themselves—with their faculties, their administrators, and their trustees. What they do not defend, others will not find it easy even to understand, while, when they are staunch in their principles and vigilant in their practices, the record suggests that neither the federal government nor any other source of support is an overwhelming threat to them. Courage and vigilance are essential, but there is no ground for a timid mistrust of government in and of itself. The right concept is that of partnership, with each partner respecting the rights and responsibilities of the other. For this there is need for a constant effort of communication and understanding, and we repeat that the first responsibility here rests with university people.

Yet the main trouble in the universities is not a failure of understanding or communication; it is lack of means. Typically the American university is trying to do too much with too little. Its salaries are low; its teaching assignments are high; its scientific buildings and equipment are cramped or out of date, or both. Modern science does not flourish in such circumstances. Dedication and talent are still the first requirements for scientific achievement, but in most branches of science today there is no escape from the need for expensive facilities and substantial numbers of colleagues. No university in this country today is doing what it should in science; none could be doing even as much as it is without the federal support which has developed in the last 15 years. Thus, partnership between the universities and the national government is the indispensable basis of first-rate university work in science.

The partnership is a fact. It has done much more good than harm. It seems certain to grow in importance unless the American people decide to accept a second-rate standing in terms of power, of comfort, and of knowledge. The broad problem which faces the government and the universities is to make the partnership fully fruitful. The remainder of this report is devoted to a number of specific issues on which it seems possible to make useful comments at this time. But particular issues are subject to change from year to year, and we do not wish to put our main emphasis on any one question in itself. In a sense these comments are illustrative rather than exhaustive or definitive; the main thing, once again, is to think of basic research and graduate education together.

Excellence Deserves Strong Support

In the advancement of science the best is vastly more important than the next best. Mediocre research is generally worse than useless, and the same may probably be said of teaching. It is, therefore, of first importance that national support for both activities should aim at sustaining and reinforcing outstanding work wherever it may be found. Both the federal government and university administrators should be firm in their support of what is first-rate, even when such support requires hard choices.

In this respect, the programs of the government since the war deserve considerable praise. In its support of basic research the government has usually relied on the advisory judgment of respected scientists, and in the main this advice has ensured that, in those areas of research in which federal support has been available, outstanding men have been able to attract substantial support. In this respect the project method of research support has real values which should not be forgotten in our proper concern for additional methods of action. As federal activity expands and broader objectives are included, we should never lose sight of the need for qualitative judgment. Nor should we ever suppose that those scientific centers which have achieved outstanding quality are somehow, by that reason, self-sustaining and free of need.

Centers of Excellence Needed

Equally with the importance of sustaining what is already outstanding, we urge the importance for the country of an increase in the number of universities in which first-rate research and graduate teaching go forward together. The growth of science requires more places with superior faculties and outstanding groups of students. Existing strong institutions cannot fully meet the nation's future needs. It is true that experience is casting doubt on some conservative notions about the optimum size of the university, and the universities which are already great are larger than they expected to be ten years ago. But there is a limit to such growth, and we must hope that where there were only a handful of generally first-rate academic centers of science a generation ago and may be as many as 15 or 20 today, there will be 30 or 40 in another 15 years. Timely and determined support to the rising centers will be repaid many times over in service to society.

Graduate Education Needs Expansion

While we believe that the basic structure of graduate education is sound, we are sure that university faculties can do much to improve it. We believe that the most important graduate degree for scientists will continue to be the Ph.D. Obviously, it is the substance of graduate training and not the formal title "Ph.D." that counts, but in our opinion there is not much point in denying the dominance of this particular degree as the outward symbol of advanced scientific capacity.

As our whole report emphasizes, we believe that graduate education leading to the Ph.D. should include a genuine experience of research. It is experience of research that makes a man a scientist. We think this kind of graduate education is needed not only for those who go on in university science but also for college teachers and, increasingly, for the more important scientific and technological positions in industry and government.

Thus, we need more men and women with the advanced training the Ph.D. symbolizes. No fixed projection of exact numerical needs seems convincing to us, and there is a sense in which we can always make do with what we have. But in terms of return on an investment, again, we believe that a steady and rapid growth in our national output of scientists, in all fields, will be well worth while.

Attracting Talented Students

If we are to have more good scientists, the first necessity is that more of our talented young people should want scientific careers. It is here that our colleges, whether or not they are parts of universities, can contribute largely. We believe that both colleges and the federal government should give urgent attention to the quality of collegiate instruction in the sciences. The first and greatest need is to extend to the college the connected concern with teaching and investigation which we have emphasized throughout. This does not mean that every college must be a university, or that every college teacher must be a dedicated research man, but

it does mean that the opportunity and practice of scientific inquiry should be a part of the life of the college laboratory. This is not an easy goal; even in universities the teaching of undergraduates is often sharply separated from the research life of the institution. But once the problem is squarely recognized, much can be done. Decent salaries, time for research, facilities for good scientific activity, and modernization of curriculum can all be helpful. Indeed, the short way of saying it is that most of the comments and conclusions we offer with respect to graduate education can be applied with only moderate adaptation to scientific work in the undergraduate liberal arts college. We repeat that nothing can do more for the supply of talent to the sciences than a general renewal of life and energy in collegiate science (*3*).

Other ways and means of strengthening the attraction of science as a career have been discussed in earlier reports and need only brief reference here. Exposure to the fascination of science should begin long before college, and at every level, and it is time for an end to the separation that has developed between college and university scientists and school teachers. We enthusiastically commend the steps toward reunion which have recently been taken by agencies of government, by school teachers, and by university scientists. There are many urgent reasons for this general course of action, but one important consequence of a new and lively connection of leading scientists to what is done at school can be a major reinforcement of the number of scientists in the next generation.

Graduate Education Needs Modernization

Our basic acceptance of the Ph.D. degree does not imply any similar acceptance of all that is now done in its name. We think it urgent that graduate education be constantly revised and improved. As science itself rapidly advances, we need new ways of teaching and learning both traditional and emerging subjects. Many university departments are more rigid in formal requirements—and more lax in insistence on real achievement—than they ought to be. Many traditional programs for the Ph.D. are now a poor preparation for serious contemporary research, and too few university scientists have given proper thought to the ways in which the learning of science can be improved at all levels by imaginative changes of method. We are at the edge of great advances in our scientific knowledge of what the process of learning is, and it would be an irony if science itself were to lag in the application of its own achievements. Fortunately, there appears at present to be a marked revival of interest among scientists in the improvement of both teaching and learning.

Financing Graduate Education

Graduate studies leading to the Ph.D. are very expensive, both for the university and for the student, and neither party is adequately supported. Great improvements have occurred in recent years, but a great deal still needs to be done. Lack of financial means is probably the greatest single difficulty faced by the American graduate student. It is lack of means, for example, that is mainly responsible for the undue length of time so often consumed in achieving the Ph.D. degree. Too many students simply cannot find the money for sustained full-time study and drop out, or take part-time jobs that delay their progress and flatten their spirits (*4*).

Fortunately, the general need for improvement in this situation is now widely recognized. The universities themselves, the major private foundations, and the federal government have all taken a hand here. But once again, because of the size and urgency of the need, we believe that the level of federal support should steadily increase.

The best and most direct form of support for graduate education is the graduate fellowship. The government has a number of such programs, and on balance they have been highly constructive. We believe that these programs—and in particular the well-designed and effective fellowship programs of the National Science Foundation—should be expanded just as fast as truly promising candidates can be found. A properly designed fellowship program is highly rewarding in its eventual return on every dollar invested.

Fellowship programs have another special value in that they can readily be designed not only to support excellence where it already exists but also to encourage new centers of outstanding work. When such fellowships are awarded directly to individuals who are free to work wherever they choose, the winners do tend, on the whole, to register in departments of established quality. On the other hand, the establishment of fellowships at a particular promising place can be a powerful reinforcement of its efforts to establish itself securely. We favor both forms of fellowship, and again we call attention to the use of both by the National Science Foundation. The various activities of the Department of Health, Education, and Welfare, especially the programs of the National Institutes of Health and the provisions of the National Defense Education Act, also serve both these ends. Thus, our double insistence on the support of existing excellence and the encouragement of new centers has sound precedents.

The natural selection and selective reinforcement which can be supported by fellowships seem to us to constitute a strong argument for including in every fellowship a substantial additional grant for the support of the institution itself. The cost of graduate education to the university always far exceeds the tuition charged to the individual, and therefore university authorities have regularly pointed out that without a supplementary grant they must expect to "lose money" on each fellowship winner. This in itself may not be a wholly persuasive argument, since the university's other resources are at least partly aimed at this same educational purpose. But we believe that fellowships are a good instrument for effective distribution of general support to universities where it will do the most good. We therefore recommend that, as a general rule, graduate fellowships supported by the federal government should include a substantial supplementary grant for the general support of the related work of the university. Since the average graduate student in science costs his university not less than \$3500 a year (*5*), grants which provide this amount to the institution would not be excessive. (Where tuition is already covered by the basic fellowship grant—the usual case—the supplement should of course be reduced accordingly.)

Fellowships are of course not the only means of supporting graduate education. Research projects provide legitimate part-time work for many degree candidates, and in many universities part-time teaching is also an effective means of serving the interests of all parties. These instruments are

not without hazard; it is possible to do much harm to a young scientist either by subordinating his need for a lively research experience to the requirements of a large organization or by exploiting his first enthusiasm for teaching by assignment exclusively to routine pedagogical tasks. In a properly designed graduate education, these legitimately remunerated forms of experience should be designed and administered with a steady eye for their effect on the graduate student as well as on his pocketbook. This is an urgent issue in many departments which otherwise have very high standards.

But once the emphasis is placed squarely on the student's need for the best possible experience in graduate school, assisting in the research of others and sharing in the work of teaching can both be intensely valuable parts of a good education, and in our eagerness to prevent abuse we should not make rules which cut students off from such opportunities. In particular, fellowship programs should not exclude the student from part-time assignments in research or teaching, and unless the fellowship is so large as to make any additional stipend unreasonable, there should be no obstacles to an appropriate payment for such services.

Ideally, perhaps the best way of financing graduate education would be to take the dollar sign off each of its separate component elements, entwined as they are, and give full support to the student from a general pool of money, while arranging his work in research, learning, and teaching so that in part it would meet the needs of others beside himself. As we work gradually toward such a result we can at least make sure that separate programs, each good in itself, are administered with full respect for the general purpose of graduate education.

Need for Improved Facilities

The dramatic expansion of science in this country has outrun our ability to provide up-to-date space and equipment for either research or teaching; still less can we provide for the two together. While, in the end, men are more important than facilities, the immediate bottleneck today, in many fields and in many universities, is in buildings and equipment. In part this backwardness is the result of a widespread and quite erroneous notion that it is less fruitful to pay for a building or for its maintenance than for research or teaching in themselves. Very little good laboratory work can be done without a roof, and in experimental science the best equipment is usually the true economy.

These propositions carry a moral both for universities and for the government. Neither side should expect to develop first-rate programs without appropriate space and equipment, and on both sides an increased emphasis on investment in facilities is desirable. We warmly approve the recent general endorsement of facilities grants by the executive branch, and we particularly commend the initiation of programs in this area by the National Institutes of Health and the National Science Foundation. While we do not believe there is any permanent magic in the matter, we see considerable practical advantage, for the present, in the practice of sharing the costs of such facilities between the federal government and other sources. Grants contingent upon some degree of "matching" tend to encourage other sources of support, and to ensure that the receiving institutions have a serious commitment in the field concerned. The heavy overapplication for funds available under these programs suggests that, for the present at least, federal money will be most productive if it is used in this way. Obviously, when the government has a particular interest in a particularly expensive installation of more than local importance, it must expect to meet all or nearly all the cost of the undertaking. There may also be other circumstances in which a particularly good opportunity for progress would be lost if "matching" were insisted on, and we believe that unmatched grants should be made in such cases.

New Fields of Research and Education

As we have already said, the national interest demands particularly rapid growth of research and training in a number of fields. The identification of these fields is a job for scientists, universities, and the government, all working together, but since the national interest *is* involved, particular responsibility for their support rests on the government. In such efforts the government must at times be willing to concentrate its support in relatively few places, and universities must avoid a log-rolling insistence on dispersion of efforts in many places at once. Moreover, in its support of these new subjects the government should place its bets where there is clear evidence that the institution concerned is prepared to establish and encourage programs of graduate education fully connected with new research.

This is no place for an exhaustive discussion of the particular subjects that are urgent today. The government has already recognized the existence of special needs in a number of fields; general examples are the sciences closely related to health and to nuclear physics (including high-energy physics and other subjects only distantly related to military strength). More recently and more specifically there has been a proper special concern for such large fields as materials, meteorology, and oceanography. These newer interests frequently have the important characteristic that they are interdisciplinary. Often this overworked word means nothing except that existing departmental divisions do not recognize a subject which has itself all the intrinsic qualities of a separate discipline. But there are also topics which really do require cooperative attack from many branches of science, and studies of materials, the oceans, and the air have this broader and truly interdisciplinary character. In such cases both the universities and the government must be particularly energetic and imaginative in seeking effective ways of encouraging basic research and graduate education together, though in a really new field, research will necessarily precede any large-scale teaching program.

The fields we have mentioned are merely illustrative. Well within sight, but in areas not yet closely studied by the federal government, are opportunities just as striking. Because the government can often be a source of stimulus to academic institutions wearing the blinders of existing departments and divisions, we think that particular attention should be given to such new topics. Again for illustration only, we suggest that there is great promise in such an emerging subject as the general study of complex systems of action, within which such very large questions as the communication sciences, cognition, and large parts of biology itself might conceivably be treated as special cases.

Avoiding Research Installations

The central proposition of this report is that science and the making of scientists go best together. This means that when it can be managed, basic research should be done in, or at least in association with, universities. Exceptions to this rule are numerous, of course. Some problems, by their nature, require attack in ways that are not suited to university life; work of the Geological Survey, for example, can hardly be divided among the universities, yet it requires science of high quality, and basic research is essential to the whole undertaking. The same thing is true of many other enterprises of government and industry. Yet we hold to the view that in the absence of special considerations the university is the best place for basic research, and we note that the separate installations which do the best work are, as a rule, those which have a close and effective connection with academic centers. The Geological Survey, in its intimate relation to academic geology, is an excellent case in point.

When a new field of interest becomes urgent, there is always a temptation to believe that a new and separate research installation is the easy answer. In basic research, at least, such a conclusion is usually questionable, and this temptation should be resisted. As a general rule such new undertakings should be made working parts of universities—or of groups of universities, if the size of the enterprise justifies the additional administrative trouble involved in such joint ventures.

The Universities and New Laboratories

Since the beginning of World War II there have developed a number of major research installations which are supported by federal money and operated by universities or groups of universities. At their best these installations have greatly contributed both to research and to education; we believe that this particular form of partnership between government and universities deserves encouragement and improvement.

We specifically reject the view that such large operations as those of the Ames Laboratory of the Iowa State University are inevitably alien to the university. We believe that great fields of research like nuclear physics simply must not be cut off from universities just because they now require very large instruments and correspondingly large staffs of specialists and technicians. The very difficulties of such large laboratories, in our view, are an argument for strengthening their connection to the universities.

In the best cases these laboratories have derived the following advantages from their university connection: they have had the active participation of outstanding university scientists; their own ability to attract first-rate research men has been strengthened by the university's sponsorship; they have been stimulated to high standards of excellence by the standards of the university itself. At the same time the university has benefited from opportunities for research and for the advanced training of graduate students, and its own ability to attract first-rate scientists has been strengthened.

It is true, however, that all such installations have their dangers, and none of them now is perfect. It is essential that the mission of such laboratories be appropriate for university sponsorship. Development as distinct from basic research, and the training of technicians as distinct from graduate education, usually belong outside the university framework. Moreover, the large laboratory confronts the university with problems of policy that are new, and there is a real danger that there will be a destructive separation between university men and laboratory men. When that happens the university loses the opportunity for a great enrichment of its graduate education, and the laboratory loses the stimulus and the support of the university's scientific staff.

We believe that members of such research installations should be more fully associated with teaching in the universities than is now usual, and conversely we think the installations themselves should always be full of learning students. All concerned should guard against the dangers of bureaucratized "team research," and the installation should be directed with a steady sympathy for new ideas. Government must avoid policies which make such flexibility difficult, and university faculties must work hard to make members of the laboratories members of the university community as well. We have no sympathy with the academic snobbery which occasionally treats as "outsiders" the members of a large special laboratory. New levels of connection and understanding are needed if we are not to have two mutually repellent races of men in our universities—the teaching faculty and the research staff. It is not enough that a small number of senior professors should preside over both sides of life; the two can be, and must be, connected in many other ways.

Nonacademic Research Scientists and Graduate Education

In spite of the basic line of argument we have set forth in this report, American science is and will continue to be much more than the work of universities and directly affiliated laboratories. Great government-supported or government-operated installations like those at Argonne and Bethesda are national assets of high scientific importance, and the same is true of many an industrial laboratory. In some fields of science leadership is no longer clearly in the universities, and basic engineering research often requires kinds of activity that do not fit easily into them. Thus there is a large and growing sector of American science which is not directly included in our central analysis, and the question arises whether in this sector there is anything that can be done to advance the fruitful connection between basic research and graduate education.

We believe that in this area there are indeed important opportunities that require exploration and exploitation by industry, by government, and by universities. Perhaps the simplest notion, and one of the best, is that it should be possible for research scientists in governmental or industrial laboratories to contribute to the graduate programs of nearby universities. This happens now, of course, but it should happen much more often; all parties should be eager to expand the practice. Government and business will serve their own interests by facilitating such teaching even to the extent of helping to pay for it, and universities for their part should be hospitable to qualified men even though they have chosen to pursue their research outside the academic fold.

There are many other avenues of fruitful interconnection between universities and government or industrial scientists: graduate students can learn much from a summer in an industrial laboratory (although such work should not be part of the degree require-

ments); academic scientists can and do serve with distinction as consultants; a year back at the university can refresh a government scientist; postdoctoral study can often be done as well at an outside installation as in the university itself. We believe that the interpenetration of academic, governmental, and industrial science is only in its opening stages, and we are sure that those who bravely press the effort to find better connections will be well rewarded. In this effort all concerned must of course protect their own standards and purposes. The university cannot become the servant of a particular company or agency. The industrial research laboratory cannot neglect its own mission. Any good thing, like associating industrial scientists with universities, can be overdone. But once again the right note, we think, is one of hope, not fear.

Supporting Postdoctoral Studies

One major element in strengthening both graduate education and basic research can be the postdoctoral fellow, who is ideally equipped to combine research with learning, and both with a share of teaching. We believe that the nature of modern science makes it necessary that there should be many more members of this rapidly growing class; both universities and the government should recognize that such postdoctoral work is as necessary, and at least as expensive, as any other form of advanced training. Postdoctoral fellowships may have particular value in the development of new interdisciplinary fields; regular and rigorous exposure to a standard doctoral discipline is often an excellent preparation for entry into subjects which apply the tools of such a discipline to specific problems. The postdoctoral fellow is free to make this important and difficult transition.

It makes no sense to accept responsibilities for other levels of preparation and then to ignore this increasingly important higher level of work. Universities, in particular, should seek ways of budgeting for the cost of postdoctoral education, just as they budget for undergraduate and graduate instruction. Tuition can as reasonably be charged for one as for the other, and state governments which have accepted the responsibility for meeting the costs of other kinds of teaching will serve their own interests well by making explicit provision for this new and growing form of higher education.

Strengthening University Faculties

The growth of science depends on good facilities and good students, but most of all upon good scientific faculties. The professor is the heart of the enterprise. Without professors the universities quite simply cease to exist. They are, indeed, so essential that we often tend to take them for granted. In recent years much good work has been done in calling attention to the shockingly low level of faculty salaries, and improvement is visible. But neither universities nor the federal government have yet recognized fully the absolutely focal role of the professor both in research and in graduate education. Both sides believe they understand the point, but both continue to tolerate policies that make it difficult for the country to have the services of an adequate number of adequately supported university scientists.

The characteristic error of most universities is to pay professors too little and to load them unwisely with specific teaching assignments. Of course lack of resources is a main cause of this error, but equally plainly part of the trouble is in a failure to understand the nature and value of a professor. Universities which pay no more than the market minimum and which make no adequate provision for research will never move into the front ranks, and will not deserve to.

And there is more to it than money and time for research. The really great scientific faculty cannot be the servant of other men—it has to be secure in its own freedom and responsibility. Too many university administrators suppose that faculties can be bought and managed like baseball teams. It is not so. Universities need brave trustees and strong administrators, but in the end they are what their faculties make them. That the United States today has a number of first-rate faculties is our greatest single scientific asset. To sustain them and to provide the conditions for the growth of more is the greatest single task of American university administrators.

In placing first and central responsibility upon the universities here, we do not mean to underestimate the importance of what government does or does not do—quite the contrary. In our judgment the general pattern of federal support for science has so far developed with very little regard for the problem of building strong faculties, and we think it urgent that careful thought be given to changes in policy that may help the universities discharge this great responsibility. The basic difficulty at present is that most federal funds are tied to specific research projects in a way which makes it hard for universities, in making long-term appointments, to rely in any way on federal funds. This difficulty is compounded in some agencies by policies which discourage the use of federal money to pay the salaries of senior faculty people. We believe that these practices and policies need to be revised in the light of the proposition that nothing is more clearly in the general interest of the federal government than a rapid increase in the quality and quantity of the nation's teaching scientists.

We do not venture to prescribe the ways in which the government and the universities can best serve their common interest at this sensitive and highly important point. Experience is a powerful teacher, and so far we have no knowledge of what can happen when the government and the university become jointly concerned with strengthening the ranks of senior scientists in our universities. There are many instruments that can be used here. At one extreme is the relatively simple practice of paying an appropriate share of the salaries of all faculty members engaged in a federally supported project; we think that this policy should in general be adopted as an interim measure, even though it often has the disadvantage of perpetuating the misleading distinction between "teaching" and "research." At the other extreme is the method, now used in Great Britain, of making large general grants for all purposes to all universities; we doubt if any such pattern could or should be accepted here. In between are such devices as the training grant, which can often be used for professional salaries, and the so-called "institutional" grant, in which broadly inclusive support is offered for a relatively large sector—say, "biological science"—over a relatively long period of time. We believe that the government and the univerisities should take energetic measures to put into effect programs in this middle ground, with the specific objective of making federal money not sim-

ply a reinforcement of scientists already holding tenure but a stimulus and a support in the appointment of more such men. We repeat that, in the general interest, a rapid increase in the number of such permanent professorial scientists is needed.

We recognize that many university scientists are strongly opposed to the use of federal funds for senior faculty salaries. Obviously we do not share their belief, but we do agree with them on one important point—the need for avoiding situations in which a professor becomes partly or wholly responsible for raising his own salary. If a university makes permanent professorial appointments in reliance upon particular federal project support and rejects any residual responsibility for financing the appointment if federal funds should fail, a most unsatisfactory sort of "second-class citizenry" is created, and we are firmly against this sort of thing. A variant of this same abuse is the practice of permitting extra pay to faculty members from grants or contracts during the regular academic year. It seems to us fundamental to the spirit of a university that a man's salary from the university itself should not be supplemented by extra term-time payments for work that is properly part of his professorial responsibilities. (Summer compensation for research work is a separate matter, since most academic appointments plainly leave the summer months free for other activities at additional compensation.) Just as a professor should not be responsible for obtaining the funds to pay his regular salary, so also there should be no bonus payment for "landing a contract."

But in our judgment the possibility of abuse is not a good argument against action. We are convinced that when a university is firm in accepting institutional responsibility for payment of all senior salaries and protects its staff from improper pressures or incentives, it can and should seek federal support for salaries as for other needed elements in basic research and graduate education.

The nation's universities urgently need to improve their own ways of giving attention to the matters described in this report. In general, university administrators need to pay much more attention to the meaning and requirements of the age of science. In particular, both administrators and faculty members need to improve their methods of dealing with the federal government. Many of the limitations and weaknesses we have found in government programs are the result of failures within the university. There is an urgent need for a stronger and clearer voice of higher education in Washington, and in particular there is need for more effective representation of those who are concerned with excellence in basic research and graduate education. Either existing agencies of representation should be greatly strengthened or new patterns of action should be sought. The choice of means belongs to the universities themselves, but in any event we believe that the leading men in our university faculties and administrations should clearly recognize that a significant investment of their own time and effort will be continuously needed in this process.

Government Policy in This Area

Today, when many separate agencies are deeply involved, when large national interests are at stake, and when programs not carefully coordinated can easily produce waste and even conflict, it is self-evident that the government should have the means for a well-coordinated and powerfully directed general policy. In our judgment, the final executive authority in this great field must necessarily lie in the office of the President, where policy can be developed with the aid of the Special Assistant to the President for Science and Technology, the Federal Council for Science and Technology, and the President's Science Advisory Committee.

A specific issue which requires resolution on a government-wide basis is that of patent policy regarding inventions that may be of practical value and which have been made while the inventors were working on government-financed projects. At present the policies of the different agencies supporting basic research vary greatly, and this creates problems both for the government and for the universities.

Under the President's policies, first reliance for designing and operating effective programs in basic research and graduate education in the sciences clearly should rest upon the National Science Foundation and the Department of Health, Education, and Welfare. But there is also a need for greater uniformity in the general practices of the many government agencies which support research in the nation's universities. The Federal Council for Science and Technology can usefully serve this end.

We do not presume to define the administrative organization that will best serve to strengthen basic research and graduate education in the nation. We do believe, however, that the President should establish, in whatever way he finds most effective, clear general policies to govern the practices of executive agencies in these areas. Any policy should, of course, be undertaken with full fiscal responsibility, but just as no university can be great if its final decisions are made by the business manager, we believe that in order for the government's programs for the support of science to flourish they must be determined by longer-range objectives as well as by budgetary considerations. Moreover, the development of federal programs to strengthen two such productive national resources as basic research and graduate education should allow for early and careful discussion with university leaders as well as for advice from research scientists outside the universities. The basic requirement is a policy of general and growing federal support both for basic research and for graduate education. Nothing less will do, if we mean to keep the position of world leadership in basic science which we now enjoy.

Private and State Support

We have urged in this report that the government should accept growing responsibility for effective support of graduate education and basic research. Our reasoning is pragmatic, not doctrinaire: government must do these things because, in view of their size and nature, no other agency can. But there is no reason to suppose that it will be good for the government to act alone, or for the rest of the forces in our plural society to stand aside. On the contrary, there is every reason for private and state funds to be sought, as eagerly and urgently as ever, and the very fact of increasing federal support makes such other help an important safeguard against the possibility of undue government influence. In the same way, the government's own plurality of agencies is valuable, in spite of the occasional confusion and duplication it can cause. Even in the best of worlds there will be things which gov-

ernment money cannot or does not do, and private philanthropy will always be greatly needed in the whole field of scientific research and teaching.

Conclusions

The following recommendations grow out of the preceding parts of this report; they indicate the lines of development which we think urgent in the immediate future. But for the reader who may turn only to the recommendations, we wish to emphasize that the record of this country in basic research and graduate education is not one of failure. American science is second to none in the world, and the federal government, on balance, has played a highly constructive role in supporting it. Most of our specific recommendations are based on our respect for the best existing practices of particular agencies of government or particular universities. These recommendations are intended not as criticisms of what has been accomplished but as proposals for still greater accomplishment in the future.

General Recommendations

1) In view of the growing importance of scientific reseach to national security and welfare, all parts of the national community should assume a greater responsibility for supporting, strengthening, and expanding basic research and graduate education.

2) In science the excellent is not just better than the ordinary; it is almost all that matters. It is therefore fundamental that this country should energetically sustain and strongly reinforce first-rate work where it now exists.

3) It is of equal importance to increase support for rising centers of science. Over the next 15 years the United States should seek to double the number of universities doing generally excellent work in basic research and graduate education.

4) It should be a general basis of policy and action that basic research and the education of scientists go best together; that they are inseparable functions of universities; that in graduate education the training of scientists involves research; and that the strength of scientific research grows out of research training in institutions of higher education.

5) To attract more talented young people to science as a career, both undergraduate colleges and the federal government should give urgent attention to the quality of collegiate instruction in the sciences. Here again research and teaching need to be connected wherever possible, so that both teachers and students may have the opportunity for learning by scientific inquiry. Better salaries, increased time for research, rising support for facilities and equipment, and modernization of curriculum—all are needed in undergraduate colleges.

6) Both the universities and the federal government should be energetic and imaginative in seeking effective ways of identifying and supporting new fields of basic research and in supporting the training of scientists in such fields. Many research opportunities are emerging in new fields that are essentially interdisciplinary; these require special efforts by universities to encourage new programs. The federal government should stimulate and support such programs where there is clear evidence that the institutions are prepared to establish programs of graduate education fully connected with the new research.

7) State, local, and private resources are needed on a large and growing scale to meet the needs and opportunities in basic research and graduate education. While this report emphasizes the responsibilities of universities and the federal government, the very fact of growing federal activity makes it urgent that state, local and private efforts also be increased, for, especially as concerns private efforts, there will always be much that the government either does not or cannot do.

Recommendations for Universities

1) Universities must continue to expand their efforts to pay proper salaries, provide adequate time and opportunity for research, and maintain an atmosphere of free learning and investigation.

2) Universities should recognize that graduate education in the sciences needs constant modernization.

3) University programs in graduate education should ordinarily include experience in both research and teaching, whether the student is headed for academic work or for industrial or governmental research. Such experience should be of a sort which advances the scientific effectiveness of the graduate student; it should not be limited to drudgery in support of the research or teaching of senior faculty.

4) Universities should give increased recognition to postdoctoral opportunities for promising students. Appropriate budgetary arrangements should be made for this form of education.

5) Universities should make full educational use of affiliated research installations. These installations should always be available to students, and members of research staffs should, wherever possible, be associated in the teaching processes of the university itself.

6) Universities should strengthen their faculties for both research and graduate teaching by accepting and using federal as well as nonfederal support for faculty salaries.

7) The university community as a whole has a duty to inform the government clearly and in detail of the nature and needs of basic research and graduate education. There is urgent need for strengthening the quantity and quality of representation of universities before both the Congress and the executive branch.

8) Universities should accept primary responsibility for ensuring that their growing partnership with the government reinforces their freedom and excellence.

Recommendations for the Federal Government

1) Federal support for basic research and graduate education in the sciences should be continued and flexibly increased so as to support excellence where it already exists and to encourage new centers of outstanding work.

2) The federal government should continue to enlarge the practice, now followed with great success in a few agencies, of providing research support over long terms and for broad objectives.

3) Once support is granted, the federal government should not seek to supervise technical operations directly. Complete scientific responsibility for all phases of a research operation should remain with the universities. Here again the best practice of the most effective agencies is a good model for the government as a whole.

4) We repeat the recommendation of

an earlier report, that "government departments and agencies concerned should uniformly modify the grant and contract provisions to permit universities and non-profit research institutions to charge full cost of research performed for the government—including overhead—and to amortize capital expenditures as an allowable cost" (*6*). This recommendation has been implemented to some extent but still requires further attention if we are not to undermine the strength of the institutions which perform the needed research. Unless research is to be cut back, the recommendation does imply increased expense; as funds increase, the further implementation of this recommendation should have very high priority.

5) Since the federal government has a deep interest in a rapid increase in the quality and quantity of the nation's teaching scientists, its agencies should in general seek forms of support for basic research and graduate education which will permit universities to enlarge their permanent faculties. In particular, the government should allow charges against all federal grants and contracts for time spent by faculty members on work so supported. (However, no such charges against grants and contracts should be permitted for extra compensation to individual faculty members during the regular academic year.)

6) Federally supported fellowship programs should be expanded when truly promising candidates can be found. Fellowships should be provided directly to talented graduate and postdoctoral students and also to selected universities for allocation to promising applicants. They should include a supplementary grant based on the full cost of such education. Such programs should not exclude the student from part-time assignments in research or teaching or from payment for such services when it is appropriate.

7) Federal support of facilities and equipment should be provided for both basic research and graduate education so as to increase the quality and quantity of research results and the number of trained scientists. Since the need for buildings and equipment is urgent, these should have high priority for the present. When the federal government has a particular interest in an installation of more than local importance, it should expect to meet all or nearly all the costs of the undertaking. In other cases, the practice of sharing the costs of facilities and equipment between the federal government and other sources should be encouraged, for the present at least, since it stimulates other sources of support and ensures that the receiving institutions have a serious commitment in the field concerned.

8) In the assignment of funds for basic research, the government should seek to promote the essential connection between the conduct of research and the training of scientists. Where it is feasible, new undertakings should be established in, or in close association with, universities, and the great influence and effectiveness of basic research in existing government installations should be increased where possible by improving its connection with graduate education and with university scientists.

9) The government should strengthen its ability to establish general policies governing its support of basic research and graduate education at universities. These policies should be formulated under the leadership of the office of the President, through appropriate advisory machinery. The planning of federal programs in these areas should allow for early and careful discussion with university leaders.

References and Notes

1. See, for example, *Strengthening American Science*, a report of the President's Science Advisory Committee (Washington, D.C., 1958); *Education for the Age of Science*, a statement by the President's Science Advisory Committee (Washington, D.C., 24 May 1959); and *Basic Research—A National Resource*, a report (NSF 57-35) by the National Science Foundation (Washington, D.C., 1957).
2. That basic research is an important element in the quality of any mission-oriented laboratory in the government was argued earlier in *Strengthening American Science* (President's Science Advisory Committee, Washington, D.C., 1958), pp. 18, 32. Nothing in the present report should be taken as a modification of that position.
3. Of course college education in the liberal arts and sciences has many other values beyond what we here emphasize; it is only in the present context that we limit ourselves to the particular and urgent topic of attracting talent to the sciences.
4. For extended discussion on this point see B. Berelson's important study, *Graduate Education in the United States* (McGraw-Hill, New York, 1960).
5. This figure is based on recent estimates collected by the U.S. Office of Education; the estimates relate to all fields of learning, and it seems most probable that scientific education is in general the most expensive kind. Estimates of cost in this field are very uncertain, but we feel confident that our figure is conservative.
6. *Strengthening American Science* (President's Science Advisory Committee, Washington, D.C., 1958), p. 34.

Tercentenary of the Royal Society

Celebrations of the Royal Society of London for Improving Natural Knowledge were held 18–26 July.

Henry Allen Moe

The letters "F.R.S." or "For. Mem. R.S." following a scholar's name undoubtedly indicate the highest scientific repute in the world, with the exception of the smaller group of scientific Nobel laureates, most of whom, be it said, were or are Fellows of the Royal Society or among its Foreign Members. This Royal Society—*Regalis Societas* in the Latin of its charters granted by King Charles II—celebrated its tercentenary during nine days, 18 to 26 July 1960; and, as Professor A. W. K. Tiselius of Uppsala—For. Mem. R.S. and Nobel laureate—said to me, these were days to remember in detail for telling to our grandsons.

The celebration was managed with the greatest efficiency, was conceived in the highest style, and expressed the most perfect taste. Its purpose, as the president, Sir Cyril Hinshelwood, O.M., Nobel laureate, said at the formal opening ceremony, was to lay an account of the Society's three centuries of stewardship before the world. To this end, books, pamphlets, and articles were prepared by Fellows of the Royal Society and members of its staff; British industry advertised the Society's accomplishments for the general good of mankind and for the development of industry; informed editorial comment praised, the Prime Minister extolled, and Queen Elizabeth II, opening the celebration in the Royal Albert Hall, declared that the accomplishments of the Society's Fellows "shine like beacons for all men to see."

All this, and more, was justified, both in the history of the Society and in the magnificence of the celebration.

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So much was published on the history of the Society, to give a basis for understanding by the delegates and the public, that it would be impossible to offer anything original. Perhaps the Queen herself summarized it better, in fewer words, than anybody else when she said:

"The Society has had an unbroken record of activity through three centuries and the contribution of the Fellows to natural knowledge is as great today as ever.

"The Royal Society has more than fulfilled the hopes of its Founder, King Charles II. He gave you the Charter and your name and he bade you apply yourselves 'to further promoting by experimental studies the sciences of natural things and of useful arts, to the Glory of God the Creator, and the advantage of the human race.' The names of Sir Isaac Newton and Charles Darwin in pure science and of James Watt, Lord Kelvin and Sir Charles Parsons in engineering science are evidence of the Society's success and recall great episodes of progress. Their contributions shine like beacons for all men to see, but let us not forget the many hundreds of Fellows whose devoted work has been indispensable to the general advance of knowledge."

But the Queen's list, if one may say so, is too short; and in the words of John Milton in *Paradise Lost,* distinguished Fellows of the Royal Society have been as "Thick as Autumnal Leaves that strow the Brooks in *Vallombrosa.*" They have been so indeed, and this is the true glory of the Royal Society.

It seems worth mentioning that Milton was not a member of the Royal Society but that his contemporary fellow poets, John Dryden and Abraham Cowley, were elected. So were John Evelyn, the celebrated diarist, and Samuel Pepys. The reason it seems worth mentioning that John Milton was not a member is this: in 1660—the year of the Restoration—the former secretary to Oliver Cromwell could hardly be an acceptable member of a society established under the Royal patronage. Besides, as Kester Svendsen has shown, Milton's science was "fundamentally classical and medieval"; and Sprat's *History of the Royal Society* (1667) was in part an attack on the kind of scientific lore woven in the fabric of *Paradise Lost* [K. Svendsen, *Milton and Science* (Harvard Univ. Press, Cambridge, 1956), p. 42].

The founders of the Royal Society of London were twelve, most of whom had met together weekly in Oxford as early as 1649, during the Rebellion, in "an experimental philosophical Clubbe." Who they were has been well-stated by Lord Adrian, O.M., F.R.S., Nobel laureate, in his review, published in the *New Scientist* (14 July 1960), of *The Royal Society—Its Origin and Founders:*

"They are a remarkable company and all the biographies have something fresh to say of them. Twelve were at the meeting at Gresham College on 28 November, 1660, after Mr. Wren's lecture when the design of the Society took shape. Two would still have international fame whether the Royal Society had been founded or not, for Sir Christopher Wren has other monuments to keep his name alive and Robert Boyle was the father of chemistry. Sir William Petty can be counted as the first to make political economy a science, and the other nine were all learned and ingenious people with scientific interests and a wide range of achievement.

"They were Jonathan Goddard who, with John Wallis, attended the weekly meetings for Philosophical Inquiries which started in London in 1645, and John Wilkins, Warden of Wadham, who joined the group after the move to Oxford in the Civil War. Viscount Brouncker was the first President of the Society in 1660. Sir Robert Moray was the soldier friend of Charles II who secured the Royal patronage, and there was Moray's compatriot Alexander Bruce, second Earl of Kincardine, whose estate soon called him back to Scotland. Laurence Rooke was an astronomer, Professor of Geometry at Gresham College, Sir Paul Neile was one of the Royalist group, famous for

his optic glasses, William Ball, another astronomer, was the first Treasurer of the Society, and Abraham Hill was a city man and a public servant. Their portraits show them all as men of ability, well versed in affairs, sensitive and keen witted or solid and capable.

"The twelve drew up a list of those 'judged willing and fit to joyne them in their design'. There were forty-one names on it, mostly of Royalists or supporters of Restoration, and a week later the Society was formally constituted. The King approved the design and 'was pleased to ofer of him selfe to bee enter'd as one of the Society'. . . .

"There are six more who deserve their place beside those who were at the first meeting: John Wallis, the mathematician, Kenelm Digby, 'skilled in six tongues and learnd in all the Arts', a link with the Court of Charles I in a more romantic age, whose life is excellently described by the late Dr. John Fulton; Elias Ashmole, who founded his museum at Oxford as a home for science, John Evelyn, the great recorder of the daily life of his time, Thomas Willis, who described the arteries of the brain, and William Croone the physician. Finally there are the two salaried officers, Henry Oldenburg, the indefatigable secretary, who edited the *Philosophical Transactions* and liked the trade of diplomacy, and Robert Hooke, the young curator who had to produce experiments for the weekly meeting, suspicious and ill-favoured and described by Professor Andrade as 'the greatest inventive genius who ever lived'. . . ."

Who were their successors, as numerous as the leaves that strow the brooks in Vallombrosa? It is possible, in the space of this article, to name only a few:

Sir Isaac Newton, of whom Leibnitz's description is certainly the shortest and perhaps the best: "a celestial genius," the greatest figure in the history of the exact sciences.

John Tyndall, whose elucidation of the blue sky was a meteorological milestone.

James Watt, perfecter of the steam engine, for whom a unit of electricity is named.

Edmund Halley, discoverer of Halley's comet.

Michael Faraday, discoverer of electromagnetic induction.

Charles Darwin and Thomas Henry Huxley.

Sir Humphrey Davy, inventor of the miners' safety lamp and discoverer of the anesthetic properties of nitrous oxide.

Left to right: Sir Gerard Thornton, foreign secretary of the Royal Society; Sir Cyril Hinshelwood, president of the Royal Society; and Detlev W. Bronk, president of the National Academy of Sciences and of the Rockefeller Institute. [Associated Press, London]

Lord Kelvin, a founder of the science of thermodynamics, improver of the mariner's compass, student of submarine telegraphy, who made the transatlantic cable practicable.

Lord Rayleigh, he of the *Theory of Sound*.

Sir Frederick Gowland Hopkins, a founder of the science of biochemistry.

Sir Charles Sherrington, a pioneer in experimental neurology.

Sir William Crookes, discoverer of the element thallium, who foretold the existence of isotopes.

Lord Rutherford, who established the existence and nature of radioactive transformations and demonstrated the nuclear structure of the atom.

James Clerk Maxwell, author of the electromagnetic theory of light.

Sir Joseph Banks, president of the Society for 42 years, a rich man with a passion for botany, who devoted much of his time and fortune to the welfare of the Society. He accompanied Captain James Cook on his first voyage of discovery in the *Endeavour* to observe the transit of Venus in the Pacific in 1769. It was Banks's clock, used on that voyage, which later was lent to Mason and Dixon for their history-fraught surveys in America.

These are some of the great dead of the Royal Society, a few of those so numerous, with pioneering accomplishment so great that they justify the words of President Hinshelwood: "According to any sane assessment the faith of 1660 has been fulfilled, and in the Tercentenary celebrations we pay tribute not only to the founding members but to all those through the three centuries who in peace or in strife, in brilliance or in obscurity, have brought the sciences to where they stand today, who have applied them to the useful arts and who have created the foundations of industry."

The faith of 1660, to which President Hinshelwood referred, was that expressed in the words of the Royal Society's motto *Nullius in Verba*, "Take no theory on trust." The motto is taken from Horace's *Ac ne forte roges, quo me duce, quo lare tuter,/Nullius addictus iurare in verba magistri.* (And do not ask, by chance, what leader I follow or what godhead guards me. I am not bound to revere the word of any particular master.)

Taken for granted now, this was not so in 1649 nor in 1660. The motto meant that the members of the Society cut themselves loose from the authority of the ancients, from the so-called Aristotelian methods of disputation which

were concerned with little beyond discussing what was already accepted as "truth." The purpose of the Society was the revolutionary one of enlarging knowledge by observation of nature and by experiment. As Professor E. N. da C. Andrade, F.R.S., has written: "The Revival of Learning in Europe may be said to have been a return to that respect for the great sages of Greek and Latin antiquity which had prevailed before the time of the so-called Dark Ages. There was in the 15th and 16th century a widespread belief among the learned that the great classic philosophers, and in particular Aristotle, had fathomed the secrets of nature, and that for those who wished to learn these secrets the right method was to study what these masters had written. . . ."

The break that the members of the newly founded Royal Society made with the authoritarian tradition was neither sudden nor complete. They had had their predecessors, on the continent and in England—in Copernicus and Galileo, in William Gilbert and Kepler and William Harvey—but the discoveries of these predecessors had not yet been incorporated in university teaching.

"From the time of the foundation of the Royal Society onwards," as President Hinshelwood said, "there was a steady increase in the number of dedicated men who by the concentration of their minds, the skill of their hands, and the sweat of their brow, worked to uncover the secrets of nature. Their labours were largely unknown to their contemporaries, they are but perfunctorily recorded by historians, and yet they have ended by transforming the face of the globe and the life of humanity."

Such was the magnitude of the accomplishment celebrated in the London of 1960.

The celebrations began on the evening of Monday, 18 July, with a reception by Her Majesty's Government in Lancaster House, a great and lavish mansion, famous in the reign of Queen Victoria as the home of the Duke and Duchess of Sutherland. Like all the evening components of the celebration it was a "white tie" affair, "with orders and decorations"; and the plumage of the males fairly outdid the gorgeousness of their ladies' gowns.

But it was on the next afternoon, 19 July, in the Royal Albert Hall, that the celebration became airborne. The Queen herself, as the Patron of the Society, accompanied by the Duke of Edinburgh, F.R.S., opened the celebration with a speech of substance and sense. She was also accompanied by the King and Queen of Sweden. The King, F.R.S., who then and there was formally admitted to the fellowship of the Society and who also made a speech of substance and sense, expressed the convictions that men of science the world over have a keen desire for helpfulness and have high hopes that their new discoveries will be used in the best ways for the benefit of humanity.

Tributes to the Royal Society were presented on behalf of the University of Bologna by Professor D. Graffli, on behalf of the French Academy of Sciences by Professor J. Lecomte, and on behalf of the recently organized Australian Academy of Sciences by Sir John Carew Eccles, F.R.S. To all, President Hinshelwood responded in their own languages as he—past president of the Classical Association and of the Modern Language Association—could have done, also, in Latin, Chinese, or Russian! The author of *Kinetics of Chemical Change* is truly in the line of descent from the 12 founders of the Royal Society whose members, as noted above, included Sir Christopher Wren, great in all his roles of mathematician, astronomer, and architect.

There never had been assembled, it is safe to say, a company of men of learning and of affairs of greater distinction and greater size than those gathered in the Royal Albert Hall on 19 July 1960: and it is safe to say that there will not be another like it unless and until the Royal Society decides to celebrate its fourth century. For no other organization, no other society anywhere, has the prestige to draw to any occasion a comparable representation of the best scholars of the world.

Ranged behind the Queen and the president of the Royal Society in the Royal Albert Hall (Prince Philip and the King and Queen of Sweden being on the dais with her) were the Fellows of the Royal Society. In front of the Queen were the foreign members of the Society and the delegates, "a great international gathering of representatives from so many countries of the world, assembled here to do honour to this occasion," as the Queen said. The rest of the hall was filled to capacity with invited guests of the Society.

It is worth mentioning, especially for the ladies, that amid the brilliant gowns of the Fellows and delegates, predominantly bright red, the Queen wore just the right dress of a yellow-green color, like young fern fronds in a dell. It was a color just right not to clash with the predominant reds—the reds of the academic gowns and hoods and the reds of the uniforms of the trumpeters and band of the Royal Military School of Music. Indeed, the color of the Queen's dress was "scientifically" right, the complementary color of the yellow-vermilion-reds that surrounded her. And her hat, a milliner's modest triumph of clustered pink and red roses, also was just right.

Ranged to the right and left of her, and overhead, were banks and domes of ferns and flowers, and the band played "A Salute to the Royal Society," composed for the occasion by the Master of the Queen's Musick, Sir Arthur Bliss.

In his presidential address, Sir Cyril viewed the history of the Royal Society in the widest context and stated many thoughts worth pondering, among which I select this:

"The task of the men of science is therefore clear. It is to go ahead undeterred by any of the uncertainties. Faith in science is not incompatible with or exclusive of any other kind of faith. Indeed there would seem to be no inconsistency in believing that scientific knowledge is itself one of the great instruments of higher ends. However that may be, duty, expediency, and the zest of living unite their voices in calling for unremitting effort, not in the certainty but in the hope and faith that knowledge may advance, mastery over environment increase, drudgery be abolished, sickness healed, the people fed, and life made happier."

Wednesday, 20 July, was given over to visits to Canterbury, Greenwich, St. Albans—as chosen by the delegates—and to lectures by Fellows of the Society on their own fields of research.

Prince Philip, Duke of Edinburgh, F.R.S., as president of the International Grasslands Congress held at Reading the week before, had at that time reminded his audience that unless we take to eating our vegetable protein directly processed, the value of grass and other herbage crops lies in their utilization by animals. The capacity of beasts to deal profitably with bulk is notoriously variable; and as the *Times*' correspondent noted, the bulk of the material put before the Grasslands Congress "has been so large that, for most of us, only a little selective grazing has been possible."

So it was also in respect to the lec-

tures of the tercentenary; only a little selective grazing was possible, and I selected the lecture on "The problems of transplantation," by Professor P. B Medawar, F.R.S., presided over by our own Dr. Peyton Rous, For. Mem. R.S. Professor Medawar's lecture was truly a marvel of lucidity and elegance, and Dr. Rous's presiding was a model of self-effacing knowledge which made just the right setting for the lecture. I can only hope that other delegates found as good grazing as I!

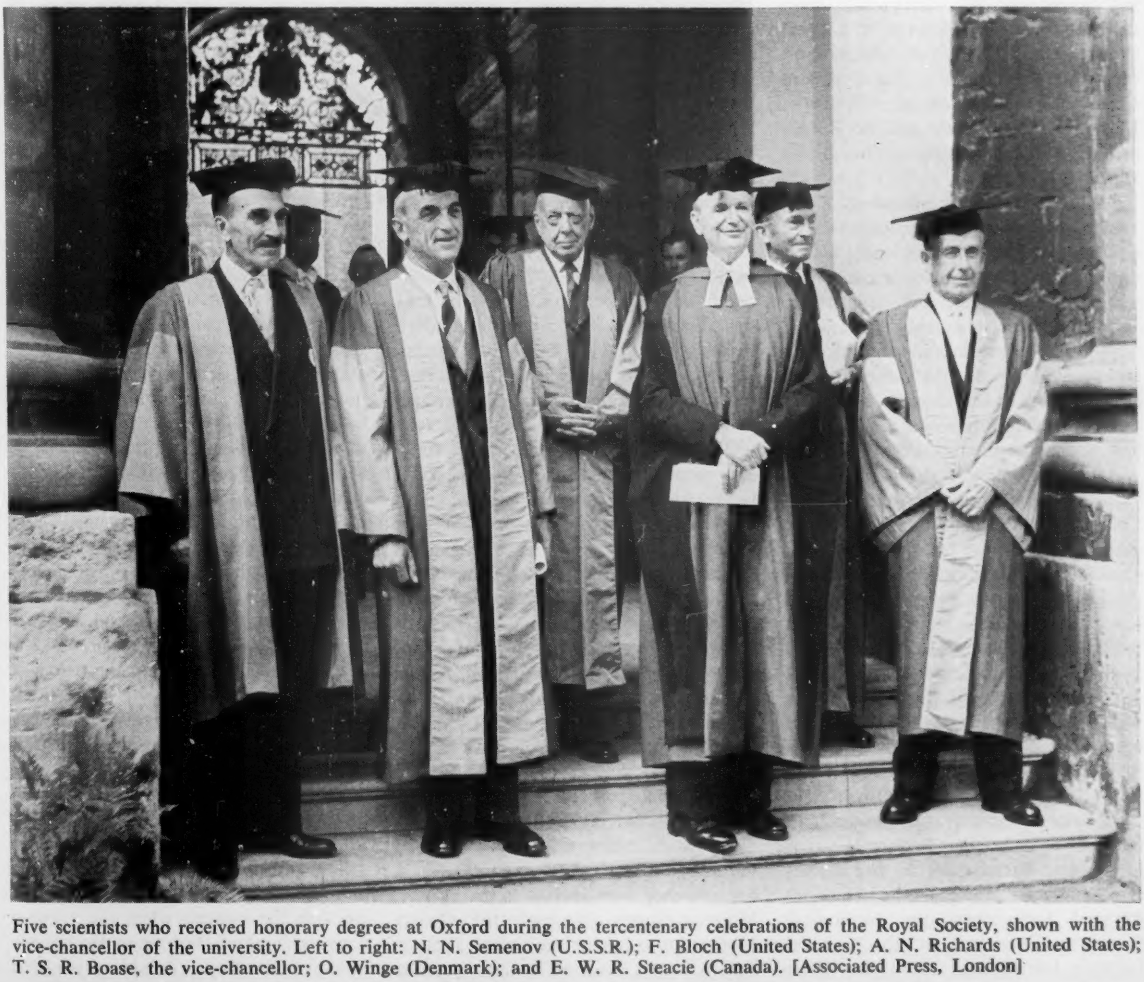
That evening there was a reception at the Senate House of the University of London—"full evening dress with orders and decorations"—at which Her Royal Highness Princess Alice, Countess of Athlone, received the delegates.

On Thursday, 21 July, the delegates were invited to the University of Oxford, and four hundred of us went up in a dozen buses. There were lunches in the college halls—banquets, indeed—and afterwards the university conferred honorary degrees of doctor of science upon five delegates. My own college being Brasenose—of which I have the honor of being an Honorary Fellow—my wife and I were invited there for lunch, and, again, I can only hope that the other delegates found as good grazing (this time in the more literal sense of food and wines) as I.

Among the delegates who received honorary degrees from the vice-chancellor of the University of Oxford, Dr. T. S. R. Boase, president of Magdalen College, was Dr. Felix Bloch, professor of physics in Stanford University, recently director-general of the European Committee of Nuclear Research at Geneva and Nobel laureate in physics. Concerning Dr. Bloch, the University's Public Orator, Mr. A. N. Bryan-Brown, said (in Latin, with English translations provided) that he had "devoted special research to metals and had been the first to show how the regularly spaced positively charged atoms so influence the negatively charged free electrons as to produce a wave-like pattern of motion." The Public Orator said much more besides about Dr. Bloch's scientific accomplishments and their practical value, and he did not omit mention of the honorand's interests in music, in mountaineering, and in the Hebrew text of the Old Testament.

Privately, the Public Orator said to me afterwards that whereas, because the ancient Romans had law, it had been comparatively easy to present me for the D.C.L., as he had done the week before, the job of characterizing a modern scientist in Latin took a good bit of doing! The Public Orator's modesty was equal to his performance and vice versa.

The other American to get an Oxford D.Sc. that day was Dr. Alfred



Five scientists who received honorary degrees at Oxford during the tercentenary celebrations of the Royal Society, shown with the vice-chancellor of the university. Left to right: N. N. Semenov (U.S.S.R.); F. Bloch (United States); A. N. Richards (United States); T. S. R. Boase, the vice-chancellor; O. Winge (Denmark); and E. W. R. Steacie (Canada). [Associated Press, London]

Newton Richards, physiologist, professor emeritus of pharmacology of the University of Pennsylvania, For. Mem. R.S. The Public Orator said, in Latin, of Professor Richards, "The Latin gender rhyme reminds us that 'ren' is masculine: otherwise we pretty well forget the kidneys, provided that they are functioning properly. Our guest, though he has never qualified in medicine, has made many contributions to science, the best known of which is perhaps the elegant essay in physiological technique which threw so much light on the fundamental secretory processes of the kidney." The Public Orator then spoke of Professor Richards's expert and timely help to Britain during both world wars and hailed him as "a vigorous veteran in the field of science . . . a Foreign Member of the Royal Society."

The other honorands were: Academician Nikolai Nikolaevitch Semenov, Nobel laureate, For. Mem. R.S., director of the Moscow Institute of Chemical Physics; Dr. Öjwind Winge, For. Mem. R.S., professor at the Carlsberg Laboratories in Copenhagen; and Dr. Edgar William Richard Steacie, F.R.S., president of the Canadian National Research Council.

As the Oxford correspondent of the *Times* wrote: "It was indeed a great day in Oxford for Natural Science; but it was also perhaps some triumph for *Literae Humaniores*; for the Public Orator, in describing the fantastically complex developments in scientific discovery in which the distinguished honorands had been so prominent, continued to demonstrate that the Romans had words for them."

Afterwards, there was a party, in full sunshine, in the garden of Wadham College—most fittingly at Wadham, for there it was that the Oxford progenitors of the Royal Society had met, during the pre-Restoration years, in the lodgings of the Warden of Wadham, John Wilkins, later Bishop of Chester.

And so back to London by bus.

The delegates and their ladies who had not chosen to go to Oxford had been offered other fare: visits to the Royal Greenwich Observatory, the John Innes Horticultural Institution, the National Institute for Research in Nuclear Science, the British Museum of Natural History, all former homes of the Royal Society, the National Physical Laboratory, the Geological Survey and Museum, and the National Institute for Medical Research. Those who went to Oxford can only hope that the others' grazing also was first class.

On Friday, 22 July, there was, in the Royal Festival Hall, a ceremony for the conferment of honorary degrees by the University of London, presided over by the chancellor of the university, Her Majesty Queen Elizabeth the Queen Mother. The following were made doctors of science:

His Majesty King Gustav VI Adolph of Sweden, F.R.S.

Dr. Homi Jehangir Bhabha, F.R.S., director and professor of theoretical physics at the Tata Institute of Fundamental Research, Bombay, India.

Sir Macfarlane Burnet, O.M., F.R.S., professor of experimental medicine in the University of Melbourne, Australia, and director of the Walter and Eliza Hall Institute of Medical Research.

Dr. George Charles de Hevesy, professor of chemistry in the Research Institute for Organic Chemistry, Stockholm; Nobel laureate, For. Mem. R.S., winner of the second "Atoms for Peace" award.

Sir Thomas Ralph Merton, F.R.S., professor of spectroscopy in the University of Oxford.

Dr. Detlev Wulf Bronk, For. Mem. R.S., president of the Rockefeller Institute, president of the National Academy of Sciences, of whom the Public Orator said, in English (with no Latin translation provided!): "As an administrator and co-ordinator of research he has played a unique part in the modern history of the United States of America . . . but with it all has retained the essential humanity of a great man, known by his familiar name of 'Det' to a very wide circle of friends and fellow-workers, from President Eisenhower down to his junior colleagues, and to many old friends and well-wishers in this country."

That afternoon, at three of the clock, there was, at the Royal Festival Hall, the showing of the film *The Opening Ceremony Recalled* (glimpses of Tuesday's proceedings in the Royal Albert Hall caught by newsreel cameras) and of two scientific films, made by the Shell International Oil Company for the tercentenary.

After the films there was a tea at the Royal Festival Hall given by the Shell International Oil Company; but the delegates' ladies did not tarry for it because they were invited to tea by Her Majesty Queen Elizabeth the Queen Mother, to a reception at St. James's Palace. It was reported by those present that the Queen Mother charmed all with the graciousness of her hospitality and by the breadth of her conversational interests. At St. James's Palace the delegates' ladies were charmed, too, by meeting the Queen Mother's ladies-in-waiting, wearing the beautifully appropriate jewels of their office.

With just time for a hurried dinner, that very evening there were receptions, in full dress, by the Lord Mayor and Corporation of the City of London at Guildhall and by the Twelve Great City Companies at the Mercers' Hall. Again, alas, one had to choose between competing magnificences, in obedience to the physical law that no body can be in two places at the same time.

At the Guildhall, the Lord Mayor and Lady Mayoress received the Fellows of the Royal Society and the delegates and ladies in medieval grandeur, flanked by sheriffs, aldermen, pikemen, and sword-bearers. The gold plate of the Corporation of London was on view, there was music, there was champagne and hock, there was food and coffee. In the Library adjoining the Guildhall proper there was a display of books and manuscripts, and the manuscripts were the more thrilling because they had not been collected and brought there but were in their right place—such as William the Conqueror's grant of the freedom of the city to a citizen in 1066.

On Saturday morning, 23 July, there were scientific lectures by members of the Royal Society; but many delegates, and especially their wives, were beginning to think that unless they husbanded their strength they would be unable to go the full course. But if they took that excuse they missed a great presentation by Dr. Dorothy Hodgkin, F.R.S., on "Molecules in crystals." And they missed getting a clear understanding of what the Queen had said in the Royal Albert Hall: "there is another change that gives me special pleasure even though it has taken almost 300 years to make. It is the admission of women to your fellowship and I am delighted to see the increasing part they are taking in scientific work in this country."

What grazing those who sought pastures, other than Dr. Hodgkin's, found, I cannot say.

The afternoon was mercifully free: nothing to do until eight-thirty of the clock in the evening when there was a *conversazione* at Burlington House, the home of the Royal Academy of Arts,

of the Royal Society, and of several other scientific societies. On display were the greetings of organizations represented at the tercentenary—arranged alphabetically from Argentina to Yugoslavia. Prince Philip and some 2000 guests attended.

Whether or not Prince Philip singled out other greetings for his special attention I cannot say, for of course I was standing by the greetings of the American Philosophical Society. But he certainly did indicate his approval of the greetings conveyed by the successors of Benjamin Franklin, F.R.S.

There was champagne and there was hock, and sandwiches; and even more important, there were scientific exhibitions of 15 avenues of research in which British scientists had had important parts in the past dozen years, including radio astronomy, refined methods of chemical separation, the molecular structure of biochemical systems, the origin and transmission of nerve impulses, and so forth.

And so to bed, wondering what the ingenuity of man might come up with in the next 300 years. A futile speculation, which, having no possible answer, seemed conducive to sleep.

The next morning, Sunday, 24 July, to St. Paul's Cathedral, designed by Sir Christopher Wren, F.R.S., to hear a sermon by the dean of St. Paul's, the Very Reverend W. R. Matthews, on "The conflict of science and religion." His point was that while religious thought moved more slowly than scientific thought, it did move—partly under the stimulus of science.

"We have to learn," Dean Matthews said, "that we who believe in God cannot afford to neglect or forget the revelation of science. Though it is not the whole truth, insofar as it is true we must accept it gladly as from God and meant for our learning. Shall we not find when we consider our creation in the light of science that our conception of the Creator has been vastly too narrow? We have thought of Him too much as like ourselves, we have been too anthropomorphic in our theology and our devotions."

Surely, Thomas Henry Huxley, F.R.S., would have been somewhat pleased with this resolution of his debate with the Bishop of Oxford, Dr. Wilberforce, exactly a hundred years before.

Sir Cyril, in his presidential address, had said of the early years of the Royal Society: "The Warden of Wadham might be a leader of the new movement: Dr. Fell, the formidable Dean of Christ Church, would have none of it. The Public Orator of the University of Oxford declaimed against the Royal Society in the theatre built by [Sir Christopher] Wren, and Antony Wood declared it to be an obnoxious body. Bishop Wilkins, Bishop Ward and Bishop Sprat might defend the new philosophy with every strength of argument and eloquence, Robert Boyle might write the *Christian Virtuoso*, every protestation and example of piety and orthodoxy might be offered by the Fellows, none of this prevented attacks from the pulpit, and the strongest accusations from other quarters. . . .

"Much of this was still reverberating yesterday and even lasts today, and in this respect the three centuries assume perhaps their shortest perspective. . . Every complaint and reproach levelled in the 17th century, every fear expressed, every resentment, interested or disinterested, openly or secretly working, can be paralleled in the recent past. Every anxiety, misgiving, criticism or reserve voiced today has been countered by the 17th century apologists. Nor can the threat of destruction by the release of nuclear energy really have exaggerated the issue, for the perils of atomic warfare are at least no more terrible than the prospects of eternal damnation to which many in the earlier age believed the new doctrines were leading men."

On Sunday afternoon, to the Victoria Station (wearing dinner jackets or full dress at two o'clock in the afternoon!) to go to the opera performance at Glyndebourne in Sussex. And the limited few who had gotten tickets were rewarded with a performance of Mozart's *Don Giovanni* of such quality that those who had heard it before, elsewhere, knew that now they had heard Mozart at his best.

Monday morning, 25 July, early by bus to Cambridge, and there the hundred Cambridge Fellows of the Royal Society were joined by three hundred Fellows and delegates from elsewhere. First, there were luncheons in the Cambridge colleges, quite the equal of the Oxford luncheons, as those of us who were entertained at Trinity—where presided the master, Lord Adrian, and his Lady—can and do testify.

Later, the vice chancellor, Professor Herbert Butterfield, master of Peterhouse, conferred the honorary degree of doctor of science upon four eminent scholars: Sir John Eccles, F.R.S., president of the Australian Academy of Science, professor of physiology in the John Curtin School of Medical Research, Australian National University; Professor Sven Otto Hörstadius, professor of physiology in the University of Uppsala, For. Mem. R.S.; Professor Bernardo Alberto Houssay, director of the Institute of Biology and Experimental Medicine, Buenos Aires, physiologist, Nobel laureate, For. Mem. R.S.; and Professor Jan Hendrick Oort, professor of astronomy at the State University of Leiden, For. Mem. R.S. As at Oxford, the Orator, Mr. L. P. Wilkinson of King's College, presented the honorands in Latin (an English translation was provided). After the ceremony, Trinity and St. John's Colleges gave a garden party on the justly famed "backs" along the River Cam.

For the delegates who did not go to Cambridge, there were scientific lectures and visits to Greenwich, to the Wellcome Research Laboratories, and to other places of scientific and esthetic interest.

Tuesday, 26 July, the final day of the celebration—morning and afternoon, were devoted to visits, at the delegates' choice, to the East Malling Research Station, the Bradwell Nuclear Power Station of the Electricity Generating Board, Whipsnade Zoological Park, National Institute for Research in Dairying, Rothamsted Experimental Station, Royal Aircraft Establishment, Chester Beatty Research Institute, Lister Institute of Preventive Medicine, Hampton Court Palace, Houses of Parliament, Goldsmiths' Hall, and other places of interest.

In the evening, at Grosvenor House, there was the tercentenary banquet, with some 1300 persons in attendance, presided over by President Hinshelwood, who proposed toasts to the Queen, to Queen Elizabeth the Queen Mother, to Prince Philip, Duke of Edinburgh, to other members of the Royal Family, and to "the pious memory of the Founder." A toast to the guests was proposed by Lord Adrian, and responses were made by Dr. F. C. James, principal and vice-chancellor of McGill University, and by Dr. A. H. T. Theorell, Nobel laureate, For. Mem. R.S.

The Prime Minister, the Rt. Hon. Harold Macmillan, M.P., proposed the toast of the Royal Society.

"If you are going to succeed in the modern world," said Mr. Macmillan,

"you have, generally speaking, to be some sort of specialist, to know a great deal about some particular branch of knowledge. This applies to everyone nowadays—except, of course, politicians" (and he ad-libbed that "the only amateurs left are the politicians!"). "But these men, your founders, were no narrow specialists. Sir Christopher Wren, who was your President in 1680, was an astronomer, indeed a professor of astronomy in two universities, before he was an architect. He really had two quite distinct careers; one as an experimental philosopher (as it was called) in which he studied eclipses, and the paths of the comets, and conducted blood transfusion experiments with Robert Boyle; and another career as an architect. If his reputation now rests on his supreme works of art, that mainly illustrates the truth that Art is more lasting than Science. 'A thing of beauty is a joy forever.'

"Nevertheless, Wren combined in himself the classical tradition and the new scientific method. He never divorced art from science, nor would he, I think, have understood the distinction we make today between the arts and the sciences. He brought a wonderful talent for scientific invention to the solution of the problems of architectural design."

And Prime Minister Macmillan concluded:

"Finally, in the presence of so many distinguished visitors from overseas, I need hardly remind you that the search for new knowledge is an activity that surmounts all barriers of nationality, language, creed or race.

"Since 1723 the Society has had its own Foreign Secretary and has maintained its ties above all with the Commonwealth. In the 18th century an illustrious member of the Society was the American Benjamin Franklin. After his long stay in London and his return to America, Franklin became a leading figure on the revolutionary side in the War of Independence but this did not affect the cordial relationship between himself and the Royal Society. In fact Franklin used his personal influence to prevent American cruisers from interfering with James Cook who was then voyaging in American waters. On the other hand, the war had no influence on the Society's support for Franklin's views on the controversial subject of lightning.

"There have been many other examples of the way the Society has striven to avoid rupture of relations between men of science in opposing countries during wars. This was always done without in any way wavering in their loyalty to the Sovereign. For instance Sir Humphrey Davy travelled freely on the continent during the Napoleonic wars, by special permission of Napoleon, and was even given a dinner by the leading French scientists at which, as tonight, the Toast of the Royal Society was proposed. This spirit of Humanism still pervades the Royal Society. Never was it more needed than today."

President Hinshelwood, responding to the Prime Minister's toast, said: "a list of the earliest members of the Royal Society would not contradict the assertion that the natural sciences are among the greatest of the humane studies. Yet some curious perversity of men and of fashion gradually created a situation in which the sciences were driven to an island where they seemed to be engaged in arts as strange as those of Prospero. But the tempests of modern times had cast up many from the other camp on to the isle of science and as a result understanding has grown and reconciliation is in sight."

And Sir Cyril concluded: "There would be no more worthy, nor more historically significant interpretation of these Tercentenary celebrations than to be able to regard them as the definitive healing of the rift and the return of science to its rightful place."

In the opinion of the president of the American Philosophical Society (founded by Benjamin Franklin, F.R.S.), and the secretary general of the John Simon Guggenheim Memorial Foundation—both of which have heeded Sir Francis Bacon's injunction to take all knowledge and all art for their province—there could have been no more fitting conclusion and climax to the tercentenary of the Royal Society of London for Improving Natural Knowledge.

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Science in the News

Ubell and Morrison To Receive AAAS-Westinghouse Awards

This year's AAAS-Westinghouse Science Writing Awards will go to Earl Ubell, science editor of the New York *Herald Tribune*, and Philip Morrison, professor of physics at Cornell University. The $1000 prizes will be presented on 27 December at a dinner in New York (Commodore Hotel, 6 P.M.) during the Association's annual meeting.

The judges also selected two additional writers to receive honorable mention for excellence in science writing, one in the newspaper and one in the magazine field. William Hines, science reporter for the Washington (D.C.) *Evening Star* will receive the newspaper citation. Winner of the honorable mention in the magazine field is Edwin Diamond, science editor of *Newsweek*.

News Winner

Ubell won his award for an article entitled, "How Joke Begot Theory of Universe," which appeared in the *Herald Tribune* on 11 April 1960. His article, written while he was covering a series of lectures at Cornell, compared the "big bang," or expanding universe, theory with the "steady-state" theory. The steady-state theory was lightly tossed off by Thomas Gold in a conversation with Hermann Bondi at Cambridge University, England, in 1946, and he ended his brief exposition with the statement, "There. That should take you five minutes to rip apart!" But Bondi and others since then have found no basic flaw in the theory. Ubell explained the implications of both theories and showed what observations would be necessary to invalidate the steady-state theory.

Born in Brooklyn in 1926, Ubell attended high school there and graduated from City College, New York, with Phi Beta Kappa honors and a major in physics. He has received numerous other awards, including the Lasker Award for Medical Journalism and honorable mention in last year's AAAS-Westinghouse contest. Ubell joined the staff of the *Herald Tribune* in 1948, began to specialize in science writing in 1951, and has been science editor since 1953.

Magazine Winner

Philip Morrison's prize-winning article, "Cause, Chance, and Creation," appeared in the 30 April 1960 issue of the *Saturday Evening Post* as part of the series "Adventures of the Mind." The piece contrasted the modern statistical picture of atoms and electrons with the older, strictly predetermined causality of Laplace and Newton.

Morrison was born in Somerville, N.J., in 1915, received a B.S. degree from the Carnegie Institute of Technology in 1936 and a Ph.D. in theoretical physics from the University of California in 1940. He has taught at San Francisco State College and the University of Illinois. After a year with the atomic bomb project at the University of Chicago in 1943–44, he became group leader in physics at the Los Alamos Laboratory of the University of California. He has been on the Cornell faculty since 1946.

Honorable Mention Winners

Hines won honorable mention in newspaper writing for his 23-part series of articles on "The Atomic Years" published from 12 June to 7 July 1960 in the Washington *Evening Star*.

In the magazine field, Diamond received honorable mention for his "Life in Outer Space," which appeared in the 22 February issue of *Newsweek*.

Judges

A group of distinguished representatives from the fields of journalism, science, and education selected the winners. The judges were Earl English, dean of the school of journalism at the University of Missouri; Alfred Friendly, managing editor, Washington *Post and Times Herald*; George Gallup, director, American Institute of Public Opinion; Morris Meister, president of Bronx Community College; Gerard Piel, editor and publisher, *Scientific American*; and Alan Waterman, director of the National Science Foundation.

The AAAS-Westinghouse Science Writing Awards were established to give recognition and encouragement to outstanding science writing, to stimulate public interest in science, and to foster a deeper understanding of science by the general public. The awards are made possible by a grant from the Westinghouse Educational Foundation.

Sherburne To Head New AAAS Program To Improve Public Understanding

The AAAS takes pleasure in announcing the appointment of Edward G. Sherburne, Jr., to head the Association's new program to improve public understanding of science. Sherburne, who graduated in mathematics from Massachusetts Institute of Technology in 1941, has some 12 years of varied experience in educational television, part of which has been devoted to significant science programs. At present he is statewide coordinator of educational television for the University of California and is responsible for budgeting, coordinating, and supervising television development on all seven of the university's campuses.

Background for the Appointment

For some time the AAAS Board of Directors has been considering ways in which the Association could be more effective in improving public understanding of science. More than a year ago the Board decided that it was time to find a staff member who could provide leadership in this increasingly important area—someone who would keep his eye on the entire realm of science communication to the public and use his influence to close gaps as they develop. Although no definite plans have been made, the Board's deliberations produced many ideas that are the basis for the new appointment.

At the outset, there was emphatic agreement that the appointee should not function as a news bureau chief or a public relations man. Rather, it was felt that he should have broad responsibility for helping groups and organizations of all kinds—especially those in the mass media—to provide better material on science for the public. In particular, he could help scientists and scientific associations explain their activities.

Edward G. Sherburne, Jr.

It was felt that, although the new staff member should work largely through other agencies, he might well develop independent programs—perhaps seminars to bring together scientists and editors and scientists and television people, for example. Or again, he might set up a consultation service to aid the local groups now being established in a number of cities to provide information on such subjects as water and air pollution, radiation hazards, and fluoridation.

When presented with some of these suggestions, Sherburne expressed himself on a philosophical point that he feels is essential to the development of his office. "The basic ingredient which must underlie a sound program of public education," he says, "is respect for the knowledge to be shared, and the correlates of respect for the specialist sharing it, and for the recipients. While this may be almost a truism, when matched against practice, it is often the basic cause of failure in many efforts."

Sherburne will arrive at AAAS headquarters in mid-March to launch the new program. He will be aided by the AAAS Committee on Public Understanding of Science, which is chaired by Warren Weaver of the Alfred P. Sloan Foundation. Members include Willard Bascom of the National Academy of Sciences, Allen T. Bonnell of the Drexel Institute of Technology, Victor Cohn of the Minneapolis *Star and Tribune*, Laurence M. Gould of Carleton College, Richard D. Heffner of the CBS Television Network, Paul E. Klopsteg of Glenview, Ill. (ex officio Board representative), and Dael Wolfle of the AAAS (ex officio).

SSRS Incorporation Successful

The court in Doylestown, Pa., ruled last month in favor of the Society for Social Responsibility in Science, granting a charter over the opposition of the American Legion. The SSRS applied for a charter in 1957, but the American Legion filed an opposing brief. The court appointed a Master of the Court to review the briefs for each side; the report of the Master was in the society's favor.

Yet the court overruled its own Master and decided against SSRS on the grounds that the wording of its constitution regarding the purpose of the society was vague. The constitution was rewritten to clarify the statement, but the American Legion also objected to the revised version. Months went by, then finally the court decided in favor of SSRS.

The decision makes it possible to apply for tax-exempt status. This status will help the society seek funds from various foundations with which to implement its concerns through various programs. The immediate reason for the incorporation proposal in 1957 was a desire on the part of SSRS to initiate a "Conference on the Constructive Uses of Science," a proposal which may now perhaps move ahead.

Science Foundation Establishes Social Sciences Division

The National Science Foundation has elevated its Office of Social Sciences to divisional status. Henry W. Riecken, on leave of absence from the University of Minnesota to head the office, has been appointed assistant director of the new Division of Social Sciences. (The other divisions of the foundation are the Division of Mathematical, Physical, and Engineering Sciences; the Division of Biological and Medical Sciences; and the Division of Scientific Personnel and Education.)

The change was made in recognition of the need for increased support of fundamental studies in the social sciences, particularly in view of diminishing assistance from other sources. Several large private foundations have either reduced their support of such basic research or have shifted the emphasis of their support in this field to applied research. The National Science Foundation is the major agency of government supporting basic research in the history and philosophy of science, in large areas of anthropology, sociology, and social psychology, and in areas of economics which lend themselves to scientific treatment.

Foundation director Alan T. Waterman pointed out: "The magnitude of the need is indicated by noting that for the past two years the funds granted for support of the social sciences have been only about one-fifth of the funds requested in the form of proposals. The foundation's action indicates its appreciation and recognition of the importance and quality of scientific research in the social sciences and its belief in the sustained growth of these fields."

Division To Have Four Programs

The new division will organize its support of basic research in the social sciences under four programs: (i) anthropological sciences, including ethnology, archeology, linguistics, and physical anthropology; (ii) economic sciences, including econometrics, economic and social geography, the economics of research and innovation, and general mathematical economics; (iii) sociological sciences, including demography, social psychology, psycholinguistics, and the sociology of science; and (iv) a program supporting basic research in the history and philosophy of science.

In addition to achieving a more adequate level of support for the best proposals than has been possible heretofore, the foundation hopes to assist "coherent areas" of social science research. Several requests have been received by the foundation for interdisciplinary basic research aimed at understanding complicated phenomena, such as the structure and acquisition of language; the economic behavior of units within our social system, from the individual to more complex units such as households, firms, and governmental units; and the behavior of social systems and social processes themselves. These requests indicate some of the current frontiers of social science research where rewarding progress may be expected.

Rapid Budget Increase

When the Office of Social Sciences was created in 1958, the annual budget was $850,000, dispersed among 49 grants. The present budget (fiscal year 1961) is $3.4 million; this should provide about 130 grants.

Foundation activities in the social sciences are guided by an advisory committee, now termed a divisional committee, whose members include Leonard S. Cottrell of the Russell Sage Foundation, New York; Fred Eggan, of the University of Chicago; John Gardner of the Carnegie Corporation, New York; Pendleton Herring of the Social Science Research Council, New York; Joseph Spengler of Duke University; S. S. Wilks of Princeton University; Logan Wilson of the University of Texas; and Dael Wolfle of the American Association for the Advancement of Science.

News Briefs

Tritium symposium. The U.S. Atomic Energy Commission has announced that the International Atomic Energy Agency will convene a Symposium on the Detection and Use of Tritium in the Physical and Biological Sciences, 10–14 April 1961, possibly in Vienna, Austria. The symposium, the first comprehensive international meeting on this subject, reflects the growing recognition of the uses of tritium as a research tool. Those interested in participating must submit abstracts *by 3 January 1961*, and completed papers by 1 March 1961, either directly to the International Atomic Energy Agency, Vienna 1, Kaerntnerring, Austria, or to the Office of Special Projects, U.S. Atomic Energy Commission, Washington 25, D.C.

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Karolinska's 150th year. The Karolinska Institute in Stockholm has just celebrated its 150th anniversary with a specially arranged anniversary week program that began on 29 November. Among the distinguished speakers were the following from Canada and the United States: Charles H. Best of Toronto, Francis D. Moore and Walter Bauer of Boston, and Irving S. Wright of New York.

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Influenza bibliography. The first installment in a continuing bibliography on influenza research has been released by the American Institute of Biological Sciences. Volume 1, Number 1 contains 176 references in the following categories: general and review; epidemiology; clinical; pathology; prophylaxis; immunology; virology; and animals. Approximately 2600 journals, domestic and foreign, are searched. Volume 1 contains references for the period 1 June through 31 August 1960. A separate volume, soon to be published, will cover 1 January 1957 through 31 May 1960.

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More scientists in industry. Employment of scientists and engineers in industry rose nearly 7 percent between January 1959 and January 1960, according to the National Science Foundation. This compares with only a 5-percent rise from 1958 to 1959. The proportionate increase from 1959 to 1960 was greatest for physical scientists, but the growth in number of engineers greatly exceeded the growth in other occupational groups.

The figures are based on preliminary estimates from a survey conducted for NSF by the Bureau of Labor Statistics of the U.S. Department of Labor. More than 10,000 companies cooperated to furnish the data, which will aid in developing programs designed to strengthen the country's scientific manpower resources. The foundation will publish a final report on the survey early in 1961, presenting detailed employment statistics.

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Colgate-Palmolive Research Center. The Colgate-Palmolive Company has announced the start of construction of a multi-million dollar research center adjacent to the Rutgers University Science Campus near New Brunswick, N.J. When completed, in the spring of 1962, the building will house the company's scientists working in such fields as biology, oral health, pharmacology, biochemistry, physiology, enzymology, and bacteriology. Colgate-Palmolive and Rutgers have worked closely in the past on a number of basic research projects.

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Education guide for nuclear science. The Oak Ridge Institute of Nuclear Studies has polled more than 300 colleges and universities to compile a 76-page brochure on nuclear science education programs in the United States. The main section of the publication lists in detail the degrees, courses, and facilities at each of 175 universities and notes the availability of fellowships and assistantships. A comprehensive table summarizes this information for institutions offering a formal degree in nuclear science, or offering the option of nuclear-science courses as part of a conventional degree.

The institute plans to issue subsequent editions in future years and is considering the inclusion of data for universities in other countries. Copies of the publication, *Education Programs and Facilities*, are available free of charge from the University Relations Division, Oak Ridge Institute of Nuclear Studies, P.O. Box 117, Oak Ridge, Tennessee.

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U.S. mortality rate. There were 1,656,814 deaths in the United States during 1959, a rate of 9.4 deaths per 1000, the U.S. Public Health Service reports. The rate is almost the same as that for 1956 but is more than 1 percent lower than the 1958 rate and about 2 percent lower than that for 1957.

The differences in death rates by color have become smaller over the past decade. Among males, a difference of 15 percent (lower for the white group) in 1950 had decreased to a 4 percent difference in 1959. Among females, a difference of 24 percent in 1950 had decreased to 9 percent in 1959.

Over this same period, the difference in the death rate by sex in the white population has remained relatively unchanged. The rates were 36 percent higher for males than for females in 1950 and 37 percent higher in 1959. For the nonwhites, however, the difference has increased. Rates for males were 26 percent higher in 1950 and 30 percent higher in 1959.

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Medicine. *Financial Assistance Available for Graduate Study in Medicine*, just published by the Association of American Medical Colleges, can be purchased for $2.50 from AAMC headquarters, 2530 Ridge Ave., Evanston, Ill. The 1960 revised edition is designed to aid both foreign and North American students seeking graduate and fellowship opportunities primarily in the United States and Canada. It is a comprehensive manual containing information on fellowships, funds, and prizes offered by foundations, professional organizations, federal agencies, and U.S. and Canadian medical schools.

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Silk worms wanted. Hans Laufer, an embryologist and assistant professor of biology at Johns Hopkins University in Baltimore, is seeking the aid of young naturalists and others interested in science in obtaining pupae of giant silk worms for his research. Laufer, who needs the silk worms for cellular dif-

ferentiation studies, has announced that he will pay well for each cocoon brought or sent to him at the biology department, Homewood campus. In 1948 Johns Hopkins made a public appeal for fireflies. Donors were paid 25 cents per hundred.

Most people think of silk worms as existing only on mulberry trees in the Orient and are surprised to learn that they can be found in large numbers throughout the United States. Moreover, the best time of the year to find them is in the fall and winter.

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Civilian reactor series completed. The Atomic Energy Commission has published the final volume [*Status Report on Gas-Cooled Reactors as of 1959* (TID-8518-8)] of the commission's 11-volume report on the civilian power reactor program (book 8 of part 3). The volume is available from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., for 55 cents.

A volume related to the over-all report—*Power Cost Normalization Studies, Civilian Power Reactor Program—1959* (SL-1674)—may be obtained from the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C., for $2.50. This volume (containing 164 pages of text, tables, graphs, and engineering drawings) deals with the cost estimates of the eight reactor concepts discussed in the volumes of part 3.

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Data processing school. The International Business Machines Corporation has opened a Systems Research Institute in New York that is perhaps the first industry-sponsored graduate school to educate people for advanced professional work in data processing systems engineering. Thirty-five I.B.M. computer specialists from the United States, Great Britain, Germany, and Canada reported for the opening of classes. The corporation expects to invest about $2 million annually to train eventually up to 400 people a year at the institute. The director of the institute is I.B.M. vice president John C. McPherson. The assistant director is Frank S. Beckman, formerly data systems manager of the I.B.M. Watson Laboratory.

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Fund drives. The proliferation of fund-raising health organizations is causing concern. National drives have skyrocketed from 15 in 1940 to more than 100 today; annual contributions total $1 billion; duplication abounds. For example, 19 agencies compete nationally for money to aid in rehabilitation of the handicapped; Los Angeles had 538 of the campaigns in 1959. Campaign costs vary from the United Funds' 5 percent to as high as 33⅓ percent.

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Soviet World's Fair. A World's Fair will be held in Moscow, 20 May–20 November 1967, to coincide with the 50th anniversary of the Soviet Union's Great October Socialist Revolution. The motto of the fair will be "Progress and Peace," and all nations, regardless of their political and social systems, will be invited to demonstrate their achievements in economics, science, technology, and culture. The U.S.S.R. Council of Ministers has formed a state committee for the event that will be headed by A. N. Kosygin, first deputy chairman of the Council of Ministers. N. P. Dudorov has been appointed general government commissioner. The fair will be organized in conformity with the Convention on International Fairs and recommendations of the International Bureau of Fairs.

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NBS advisory committees. Two new technical advisory committees have been established by the National Bureau of Standards, one on calibration and measurement services and one on engineering and related standards. William Wildhack, special assistant to the director of NBS, is chairman of both. The committees include leaders in specialized fields who are drawn from industry. The purpose of the two new bodies is to aid the bureau in cooperating with industry in the fields of precision measurement, calibration, and standard practices.

* * *

Poliomyelitis decreases. Incidence of poliomyelitis in the United States for the full year 1960 will be well below that for any year since the introduction of the Salk vaccine in 1955, Metropolitan Life Insurance Company statisticians predict. On the basis of the 2127 cases of the disease reported in the first 38 weeks of the year, it is estimated that there will be approximately 3000 cases by year's end. This compares with 8425 cases in 1959, and with 5485 in 1957, the smallest number for any year since 1942. About 29,000 cases were reported in 1955, and in the immediate pre-Salk era, 1950–54, the annual number averaged close to 39,000.

Grants, Fellowships, and Awards

Anthropology. Two $5000 research fellowships, the Ogden Mills Fellowships, are offered annually by the department of anthropology of the American Museum of Natural History, New York City, for anthropologists who might benefit by a year at the museum. Preference will be given to applicants who can make most use of the museum's collections and archives (unpublished field notes, films, sound recordings). These fellowships are not intended for field work, although it is possible that such activities may occasionally be included.

Candidates in their early postdoctoral years will be given preference, but there are no rigid requirements as to age, sex, degrees, or academic background. The application deadline is *1 February*. For information write to Dr. Harry L. Shapiro, Department of Anthropology, American Museum of Natural History, New York 24, N.Y.

Demography. The Population Council is offering 25 fellowships for training in the field of population at the predoctoral and postdoctoral levels during the 1961–62 academic year. These awards are available for study in appropriate universities in the United States and other countries.

Council fellowships are for training in demography, although related study in sociology, economics, biostatistics, and other relevant fields may form part of a total program. The plan of study and choice of university are made by the applicant. A candidate must have completed at least 1 year of graduate study.

Applications are accepted from well-qualified persons of all countries, preferably under 40. Particular consideration is given to students from the economically underdeveloped areas.

Fellows receive support for full-time study, usually for a period of 12 months. The basic stipend is $2700; this may be supplemented to provide for tuition, maintenance of dependents, travel, and exceptional expenses. It may be diminished to take account of lesser needs or partial support from other sources. Somewhat larger stipends are granted to postdoctoral than to predoctoral fellows.

Applications for the academic year 1961–62 should be received before *1 February 1961*. Requests for application forms should be addressed to: The Population Council, 230 Park Ave., New York 17, N.Y.

General. Grants-in-aid, usually ranging between $500 and $1500, are available from funds administered by the American Academy of Arts and Sciences for research in any recognized scientific field, including mathematics, physics, biology, and the social sciences. Applications must be received *before 1 February* for grants to be made in March, and before 1 September for grants to be made in October. In general, applications from individual scientists rather than from institutions are favored, although this is not an inflexible policy. Projects dealing with explorations of the frontiers of scientific knowledge, whether interdisciplinary or within a discipline, are preferred.

While the Committees on Research Funds are interested in applicants handicapped by inadequate facilities, requests for the purchase of nonexpendable laboratory equipment usually available in the institutions of higher learning are in general not considered. Support is not usually given for work aimed primarily at fulfilling the requirements of an academic degree.

Inquiries and requests for application forms should be addressed to: Committees on Research Funds, American Academy of Arts and Sciences, 280 Newton Street, Brookline Station, Boston 46, Mass.

Genetics. The American Society of Human Genetics has been granted funds by the National Science Foundation and the U.S. National Institutes of Health for the support of travel of a limited number of the American scientists who will attend the second International Conference of Human Genetics, to be held in Rome, Italy, 7–12 September 1961. The secretary of the American Society has mailed applications to members. Nonmembers may obtain forms from Professor C. P. Oliver, Department of Zoology, University of Texas, Austin.

The amounts granted will depend on the number of applications but probably will not exceed air-tourist round-trip fare to Rome. Maximum travel grants will be awarded to persons invited by the secretariat of the conference to participate in symposia and to applicants whose abstracts are approved by the society's Committee on Program Arrangements. Persons who will not present papers at the conference may apply for partial travel assistance; the procedure is explained in the application form.

Health physics. The Oak Ridge Institute of Nuclear Studies is accepting applications from college seniors and graduates for Atomic Energy Commission special fellowships in health physics. Applications are open to students who, by the fall of 1961, will have received their bachelor's degrees in biology, chemistry, engineering, or physics and will have completed the study of mathematics through calculus. Applicants with majors in related science will also be considered.

Under the Health Physics Fellowship Program, appointees spend the 1961–62 academic year at one of eight universities, then have 3 months of practical experience at an AEC laboratory. The fellowships may be extended in some cases into a second academic year for the completion of requirements for a master's degree.

The basic annual stipend is $2500, with an additional $350 allowed for each dependent. The fellowship also covers normal tuition and required fees and also includes a limited travel allowance.

Deadline for filing applications is *1 February 1961*. Further information and applications are available from the Health Physics Fellowship Office, Oak Ridge Institute of Nuclear Studies, P.O. Box 117, Oak Ridge, Tenn.

Pharmacognosy. The American Foundation for Pharmaceutical Education annually offers three Edwin Leigh Newcomb memorial awards for meritorious papers and essays in the field of pharmacognosy. A $250 prize is provided in each of three categories: (i) undergraduate student; (ii) graduate student; (iii) teacher, research worker, or industrial scientist. Unpublished essays or published papers may be submitted, but the latter must have appeared not more than a year prior to receipt by the awards committee. All entries, in triplicate, must be received before *1 February 1961* by Dr. H. W. Youngken, Massachusetts College of Pharmacy, 179 Longwood Ave., Boston 15, Mass.

Teacher training. The National Science Foundation supports a Summer Institutes Program that provides courses especially designed for secondary school science and mathematics teachers. These institutes vary widely in scope, including programs planned for (i) teachers with weak or insufficient subject-matter backgrounds; (ii) teachers with backgrounds that are adequate but out of date; (iii) teachers desiring more advanced training; and (iv) teachers desiring training in specialized areas. In addition to courses, the institutes provide excellent opportunities for valuable and informal contacts among the teacher-participants and the instructional staff.

Summer institutes are given wide publicity by the sponsoring institutions, which usually distribute brochures outlining their offerings. Information, including application blanks, relative to a specific institute must be obtained from the host institution, *not* from the foundation.

Participants in the Summer Institutes are exempt from payment of tuition and fees and, in addition, receive stipends of not more than $75 per week plus dependency allowances of up to $15 per week per dependent to a maximum of four. An allowance, not to exceed $80, to aid in defraying the cost of one round trip from the participant's home to the institute, at the rate of 4 cents per mile, is normally available.

The deadline for teacher-participant applications for the 1961 Summer Institutes Program is *14 February 1961*. Approximately 340 institutes for high-school teachers of mathematics and science, to accommodate a total of 17,500 teachers, are being planned.

A national listing of the colleges and universities that offer summer institutes is issued annually by the foundation. Although the list will not be available until 1 January, requests for it may be made by a post card to the NSF (Washington 25, D.C.) at any time, and the list will be mailed when ready.

Scientists in the News

Detlev Bronk, president of the Rockefeller Institute, was recently elected an honorary member of the Brazilian Academy of Science and made an honorary doctor of the University of Brazil at a special university convocation. Bronk, who is also president of the National Academy of Sciences, has just returned from an extensive trip through Brazil, where he advised on the development of science as a basis for industrial expansion. He also delivered an address at the dedication of the new building for the Brazilian Academy of Science.

Charles D. Cox has been appointed head of the Microbiology Branch of the Office of Naval Research, Washington, D.C. He has held teaching positions at the Medical College of Virginia, Pennsylvania State University, and the University of South Dakota.

George W. Beadle, chairman of the department of biology at California Institute of Technology and former AAAS president, will deliver the Philosophical Society of Washington's ninth annual Christmas Lectures for high school students and their teachers, at George Washington University on the evenings of 22 and 23 December. Beadle, who was the recipient of the Nobel Prize in 1958, will discuss genetics.

W. P. Jones, superintendent of the Aerodynamics Division of the British National Physical Laboratory, is spending 9 months as Jerome Clark Hunsaker professor at Massachusetts Institute of Technology.

Ralph O. Marts, a member of the research staff of the U.S. Forest Products Laboratory, Madison, Wis., has retired after 31 years of service. Marts is credited with the development of various techniques in the use of incident-light microscopy and photomicrography, some of which have been adapted also for use in medical research. His work in preparing specimens and in photographing the microstructure of wood earned him international recognition. Marts is also an authority on growth–quality relations as a result of his research involving springwood and summerwood development in artifically irrigated longleaf pine trees.

Brigadier General **Austin W. Betts**, director of the Advanced Research Project Agency of the Department of Defense since December 1959, has been named director of the Atomic Energy Commission's Division of Military Application, effective 15 January 1961. He will succeed Major General **A. D. Starbird** who has held the post since 1955. Starbird's next assignment has not been announced.

The University of Maryland has announced appointment of **Lorin J. Mullins** as professor and chairman of the medical school's newly established department of biophysics. Mullins has been at the medical school for a year as visiting professor of biophysics under a U.S. Public Health Service training grant. He was formerly associate professor of biophysics at Purdue University.

Also at Maryland, **Leon Bernstein** has been appointed associate professor for a year in the department of physiology. Bernstein, now assistant director of professional services at the Veterans Administration Hospital in Loch Raven, is a graduate of the University of London, where he was a senior lecturer from 1951 to 1957. He is a specialist in respiratory physiology.

Robert W. Allard, professor of agronomy at the University of California, Davis, has been granted a Guggenheim fellowship to study stochastic processes in genetics during a 6-month sabbatical leave, to begin 1 February 1961, which he will spend at Oxford in the university's biometrical unit.

Two other Davis faculty members are taking sabbatical leaves abroad. **William A. Williams**, associate professor of agronomy, is spending a year at the University of Adelaide, Adelaide, Australia, where he is conducting research on the role of light in the competitive interactions of legumes and non-legumes.

Duane S. Mikkelsen, also associate professor of agronomy, has gone to Brazil for a year at the request of the IBEC Research Institute. His work will involve development of techniques for evaluation of the nutrient status of soils and study of the primary factors limiting efficient agricultural production in Brazil.

F. Douglas Lawrason, dean of the University of Arkansas Medical School, has been appointed executive medical director of Merck and Company, Inc., with headquarters at West Point, Pa. Lawrason, who is known for his research in cancer, in leukemia, and in other fields, will be responsible for all the medical activities of the company, including clinical research on drugs.

Stephen S. Chang, until recently a senior research chemist with the A. E. Staley Company, Decatur, Ill., has been appointed associate professor in the department of food science at the Rutgers College of Agriculture. He has a special interest in the technology of fats and oils and has had extensive experience in gas chromatography.

Marius Cohn has been appointed manager of the mathematics and logic research department at the Remington Rand Univac Military Division, St. Paul, Minn. He succeeds **Abraham Franck**, who has been granted a leave of absence to accept a visiting professorship at Iowa State University. Cohn was formerly staff consultant to Franck.

Bassett Maguire, head curator and coordinator of tropical research at the New York Botanical Garden, has been elected an honorary member of the Sociedad Venezolana de Ciencias Naturales, Caracas, Venezuela, because of his extensive explorations, over many years, of the great Roraima-type mountains of the Guiana Highlands.

R. L. Reagan, professor of virus diseases since 1946 at the University of Maryland, has resigned to accept the position of chief virologist at the Jen-Sal Laboratories (Vick Chemical Company), Kansas City, Missouri. Reagan will assume his new duties in the spring.

David A. McLean, component development engineer of the Bell Telephone Laboratories, Murray Hill, N.J., has received the 1959 Miniaturization Award, sponsored by Miniature Precision Bearings, Inc., for his new concept and successful method of producing microminiature electronic components and circuitry.

Recent Deaths

William E. Anderson, Miami, Ohio; 85; professor emeritus of mathematics at Miami University; 3 Dec.

Henry Federighi, Yellow Springs, Ohio; 60; professor of biology at Antioch College for many years and departmental chairman since 1942; was on sabbatical leave in Honolulu; known for his work on the relation between temperature and biological reactions, nerve regeneration, and studies of the biology of oysters and marine worms; 30 Nov.

John T. Patterson, Austin, Tex.; 82; internationally known geneticist; professor emeritus of zoology at the University of Texas, where he served for 45 years, 11 of them as department chairman; member of the National Academy of Sciences; 4 Dec.

William H. Smith, Cambridge, Mass.; 91; member of the Harvard Medical School faculty from 1900 to 1930; was on the house staff of Massachusetts General Hospital from the time he became a physician in 1897 until he retired in 1942, as a member of its board of consultation; 1 Dec.

Erratum: The name of André Jagendorf, coauthor (with Howard H. Seliger) of the report on the McCollum-Pratt Symposium on Light and Life [*Science* 132, 1698 (2 Dec. 1960)], was omitted from the published paper.

Book Reviews

The Rebels. A study of post-war insurrections. Brian Crozier. Beacon Press, Boston, Mass., 1960. 256 pp. $3.95.

This is a fascinating and extremely informative study of a much-too-neglected subject, the anatomy of rebellion and the art of controlling rebels. Since the end of World War II the world has known no rest from internal wars; and even though there has been much discussion of how the balance of nuclear terror has increased the possibility of limited wars, there has been shockingly little serious scholarship on the subject of such forms of violence. Brian Crozier, Australian journalist and staff member of *The Economist*, has now provided us with an invaluable and lively introduction which takes the form of brief but rewarding conducted tours of almost all the postwar insurrections. These include the struggles by communists and noncommunists against both British and French colonial rule, insurrections against communist rule, and uprisings against the newly independent governments.

With remarkable economy of words, Crozier presents the roots of each rebellion and the key sequences of events so that even the previously uninformed reader can quickly grasp the essence of each situation. The scene moves from the jungles of Malaya and Vietnam to the white highlands of Kenya and the mountains of Algeria with breath-taking rapidity, but without superficiality in treatment. Specialists on particular countries and situations will be able to raise some questions of both fact and judgment—Crozier does seem to be just a bit more understanding of British embarrassments than French ones—but all must acknowledge that, as a broad work in contemporary history, this is a tour de force.

In spite of his accumulation of information, Crozier has some difficulties in advancing either completely convincing or particularly novel explanations of the nature of rebellions. Essentially, he advances the view that rebellions always stem from frustrations; political frustrations stem mainly from bad government; bad government generally means not moving with the times and forgetting that an ounce of prevention is worth a pound of cure—for example, always stay one step ahead of a people's demand for independence; and if a rebellion does break out, only beastly governments can effectively use pure repression while democratic governments must combine a search for a political settlement with their use of force.

No objections can be made to any of these points; indeed, not only are Crozier's values right, but in various contexts, he has much to say of real political wisdom on these matters. The difficulties are the intellectual ones of categorizing knowledge and demonstrating the significance of relationships. We can all agree that there should be less frustration and more good government in the world; but we can feel this way precisely because people are always frustrated and governments are never as good as they should be. The fact that we find these conditions existing at all times, including the periods preliminary to a rebellion, may or may not mean that they are relevant in "explaining" subsequent rebellions. One of the great feats of the human imagination is the ability of political man to find, regardless of the objective circumstances, a public cause for giving expression to his private problems.

The fundamental difficulty Crozier has in arriving at a typology of rebellions is that he limits himself almost entirely to the level of political and rational calculations. People can get mixed up with, and even come to lead, rebellions for a whole host of reasons ranging from the most personal to the most general. This is particularly likely during periods of great social upheaval when people feel adrift. Indeed, during unsettled times, many people may be far less interested in the objectives of a movement than in the simple act of association and participation. They may just want to belong even when bored with the announced goals, and they may want to lead even when uninspired by professed objectives. In short, all problems are not to be solved by such crude methods as administrative programs and good government; in dealing with problems common to drastically changing societies, it is especially important to recognize the tremendous gap that usually exists between personal motivations and public issues.

These observations only suggest that, as we follow Crozier's lead and begin to study rebellions more seriously, we are likely to find that we are dealing with a subject which calls for a complete examination of all aspects of the problems of creating modern men and modern societies. It would be too bad if, at the beginning of such an effort, we were to commit ourselves too strongly to the view that human frustrations are dangerous and that the objective of government should be the creation of a placid and docile population by forward-thinking, manipulative administrative programs. Another alternative, or at least a complementary approach, might be to encourage the expression of frustration, hostility, and aggression, but through socially acceptable channels; for many of the greatest achievements of mankind, from art to politics, have occurred because men have been driven on by their frustrations and even by their aggressions. As a very wise colonial official once observed, when informed that the steam could be easily taken out of native opposition movement by giving the ambitious leaders minor government jobs, "Men should have their inalienable rights to frustrations, and good government should never rest upon the buying off of discontent."

LUCIAN W. PYE
Center for International Studies, Massachusetts Institute of Technology

The Stone Age of Northern Africa. C. B. M. McBurney. Penguin Books, London, 1960. 288 pp. Illus. $1.45.

McBurney's latest contribution in the field of North African prehistory is a pleasant surprise. Too many books of this kind are so overloaded with ponderous and poorly organized masses of

detail that they have a stunning effect almost equal to that of a blunt instrument. In the present case, however, although the author has produced masses of information just as imposing as those served up by any of his colleagues, the material is beautifully organized and is presented with the easy mastery of a champion weight lifter.

The author begins by summarizing briefly what is known about the Stone Age peoples and industries of Europe, Western Asia, and Africa south of the Sahara and about the conditions under which the people lived. He then presents in great detail the evidence bearing on the Stone Age races and cultures of Northern Africa including the Sahara (from the Red Sea to the Atlantic) and on their environmental settings and ecologies insofar as these are known. The resulting broad picture is remarkably coherent and complete. It may seem to some that undue emphasis is placed on the eastern half of the desert, but that is doubtless because this is the area with which McBurney is most familiar personally. There is a good map at the beginning of chapter 1, and dozens of excellent illustrations are scattered through the text.

No book covering so vast and complex a field can be expected to be wholly free from errors of either omission or commission, and so the following critical remarks should not be taken as detracting from the unique, over-all value of McBurney's work. Apparently a considerable time elapsed between the completion of the manuscript and its publication; for I find no mention of the very important palaeobotanical data and radiocarbon datings published in 1956 and subsequently by Pons and Quézel, nor of Hugot's reports on Capsian finds in the central western Sahara. The relationship between the present sedentary agricultural population of the desert and the waves of negroid immigrants who entered it from the Sudan in Neolithic times also seems to have escaped the author's notice, although I discussed this point at length in print in 1957 and 1958.

Some of McBurney's conclusions seem to me to be open to serious question. The "Tibbu" (= Teda) of the Tibesti, for example, are surely not of "Central-African origin" linguistically, at least not according to Greenberg, nor do they seem to me to be so physically. I disagree emphatically, on somatological grounds not to mention technotypological considerations, with the assumption that "the Mechta el Arbi strain is ultimately of western origin . . . [and] brought . . . the basic traits of a backed-blade industry from South-Western Europe. . . ." The skull known as *Dar es Soltan C-1* does not belong, in my opinion, to the "Mechta el Arbi strain" but to some strain rather like that which Angell has called the "Basic White" variety of *Homo sapiens*. Nor was the "Mechta el Arbi type" ever "totally replaced by Mediterraneans," but on the contrary, was absorbed by them so gradually that even today Mechta-like individuals appear now and then among the modern Berber population of the Kabylie Mountains. I still have serious doubts regarding the supposedly neanderthaloid character of the Haua Fteah mandible which, judging by the published photographs and measurements, could easily be lost among the Mesolithic mandibles from Afalou and Taforalt. And finally, the far western trans-Saharan trade route was open not only "in the remote past" but has been in almost constant use, certainly for the last 500 and possibly for the last 5000 years.

A few factual errors have crept in here and there, but they are of only minor importance. Bir el Ater is not "in southern Tunisia" but in southeastern Algeria, some 90 kilometers due south of Tebessa and roughly 15 kilometers west of the Tunisian border; Taferjit, which lies 135 kilometers (not "some 200") west of Agadès, is hardly "in the southern Aïr." And "Akhnet" should be written (and pronounced) "Ahnet." The "Aterian tang" is found outside Northern Africa not only on Easter Island but also in the highlands of Central America. And Aterian industries are distributed far more widely, in, as well as south of, the Sahara, than McBurney leads the reader to suppose.

This rather forbidding list of critical comments and downright criticisms should not be taken too seriously, however, for the flaws noted therein are no more than scattered specks on the surface of a wonderfully complete and polished piece of solid work. McBurney's new book is certainly the standard reference work in its field for everyone who can read English easily, and it will probably remain so for a good many years to come.

LLOYD CABOT BRIGGS

Peabody Museum,
Harvard University

The Intelligent Man's Guide to Science. vol. 1, *The Physical Sciences*. vol. 2, *The Biological Sciences*. Isaac Asimov. Basic Books, New York, 1960. xiv + 853 pp. Illus. + plates. 2 vols. (boxed), $15; $11.95 (until 25 December).

Here, at last, is something new in popular science writing. For once an author has taken the whole of modern science as his oyster, and he has shown himself equal to the task without patronizing the reader, taking him for a babe-in-arms, or doing devilish damage to the contents by culling his material from third-hand sources. For at least one reviewer who started with a considerable allergy towards all popularized science, the world will never again be quite the same. It happens that Isaac Asimov is a professor of biochemistry at Boston University. More important, he is one of the most polished and imaginative writers of science fiction, and he is the author of several previous, more limited popular science books. He writes like a professional, not like a scientist speaking ex cathedra, and in two extensive fields of science, his knowledge is so far reaching that he can draw a synoptic picture far more vivid than any that have gone before.

Asimov's fields are the physical and the biological sciences. For him, physics consists of a complex of astrophysics and particle theory, while biology is a system that proceeds from biochemistry to the associated subjects of neurophysiology and genetics. All else, as they used to say of the nonphysical sciences, is stamp collecting. I happen to agree firmly with Asimov about what is central in science and what is not, and I will defend him to the death against traditionalists who might deplore his not starting with "Heat, Light, and Sound" or his giving short shrift to "Natural History." In fact, my only criticism is that he occasionally departs from the key areas, the growing tips of modern science, and digresses inconsequentially. The most notable examples of this are a piffling and incomplete chapter on technology, "The Machine," which has little to do with the rest of the book, and some over-naive judgments about the early history of science.

The main body of each volume, however, gives the most up-to-date, the most exciting, and the most readable general account of the spur heads of modern science. I would recommend these

volumes above any other popular book and above many conventional texts as being suitable for anyone, from high-school age onward, who wants to understand those parts of science where man's heaviest intellectual artillery is being deployed.

DEREK J. DE SOLLA PRICE
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Biological and Chemical Control of Plant and Animal Pests. A symposium. L. P. Reitz, Ed. AAAS Publication No. 61. American Association for the Advancement of Science, Washington, D.C., 1960. xii + 273 pp. Illus. $5 (cash price to members); $5.75.

Pesticide Handbook, 1960. Donald E. H. Frear, Ed. College Science Publishers, State College, Pa., ed. 12, 1960. 265 pp. Illus. Paper, $1.75; cloth, $3.25.

Chemical and Natural Control of Pests. E. R. de Ong. Reinhold, New York; Chapman and Hall, London, 1960. viii + 244 pp. Illus. $8.75.

The AAAS publication, a group of 19 papers presented at a symposium arranged by the section on Agriculture at the Indianapolis meeting of the AAAS (1957), is a powerful counterpoise to some of the inaccurate thinking which has found expression here and abroad on the subject of chemicals in our food. One might hope that the fuzzy thinking of the alarmists does have a useful by-product if it indeed stimulates scientists working in the field of pesticides and biological control of pests to become more articulate, as reflected in these papers. Another by-product is a more vigorous exploitation of the biological control of pests that attack our plants and animals.

The first five papers are grouped in part 1 under the heading "The public's stake in pest control." M. R. Clarkson, J. R. Hansbrough, and J. A. Beal (U.S. Department of Agriculture), E. H. Fisher (University of Wisconsin), and B. L. Oser (Food and Drug Research Laboratories) present a well-rounded picture of the need for pesticides, together with some outstanding examples of their use and regulation by the Department of Agriculture and the Food and Drug Administration.

The four papers in part 2 are grouped under the heading "Recent advances in chemical control." G. L. McNew (Boyce Thompson Institute for Plant Research) outlines progress made with the newer fungicides and antibiotics in controlling plant diseases. R. H. Beatty (AmChem Products) gives a brief history of 2,4-D and its extraordinary usefulness, and he also discusses some of the newer herbicides. J. E. Casida (University of Wisconsin) describes the behavior of some of the systemic insecticides for use on plants and animals. F. O. Gossett (Eli Lilly and Company) gives an account of the anthelmintics and other chemicals used to combat internal parasites of domestic animals.

The final 10 papers are grouped in part 3 under the heading "Biological control of pests." These are separate contributions by W. C. Snyder, C. A. Fleschner, and E. H. Stanford (University of California); J. D. Briggs (Illinois Natural History Survey); E. F. Knipling and N. F. Waters (U.S. Department of Agriculture); J. D. Rodriguez (University of Kentucky); A. D. Pickett (Canada Department of Agriculture); J. R. Shay (Purdue University); and R. H. Painter (Kansas State University). A broad range of topics is covered here, from antagonism as a plant disease control principle to the use of pathogens, parasites, and predators for controlling pests; the use of atomic radiation to sterilize male screw-worm flies, which results in their annihilation; the breeding of disease-resistant crops and animals; the effect of nutritional changes in the host and the host's reaction to parasites; disease resistance in animals; and the effect of pest control practices on biological balance in apple orchards. I recommend these papers to those who would strive for a balanced outlook on pest control and eradication. It is quite evident that (i) chemicals are extremely useful and necessary for pest control; (ii) the use of chemicals is being properly regulated; (iii) there is active exploration of biological control in its many aspects; (iv) there are new methods, such as male sterilization by gamma radiation, which will have important consequences in the future; and (v) the way is open for the combined action of both chemical and biological control methods to enable man to decrease the stupendous toll exacted by plant and animal pests and parasites.

The articles in parts 2 and 3 contain many useful references; there is a subject index. This volume is a worth while and very interesting book to have on one's shelf.

If one has occasion to look up the trade names of pesticide formulations or what they contain and who sells them, the *Pesticide Handbook* is the standard reference on the subject. Frear lists 7851 formulations and gives the contents according to their labels. A list by active ingredients is tied in through a number system with the formulations presently on the market in the United States. There is also a useful list defining the registered pesticides and their legal tolerances on certain raw agricultural commodities.

Chemical and Natural Control of Pests, if judged by its title, should cover a wide scope, but actually it is largely oriented toward insecticides and their recommended uses. Unfortunately, it requires the reader to know which insecticides recommended for use are no longer manufactured or readily available and which ones are no longer of much use against a given species because of insect resistance. The pesticides listed in the appendix have not been brought up to date with respect to the common names or the trade names. In several instances, the names used in the text cannot be found in the appendix. Despite these shortcomings, the book contains much useful information.

STANLEY A. HALL
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A Revision of the Species of Schizonycha Dejean (Col.:Melolonthidae) from Southern Africa. *Bulletin of the British Museum (Natural History), Entomology*, vol. 9, No. 2, pp. 63–218. R. D. Pope. British Museum (Natural History), London, 1960. Illus. + plates. 50s.

This is a most welcome, much needed revision of work on the species of the scarab beetles of the very large and difficult genus *Schizonycha* inhabiting southern Africa. Over 300 species of *Schizonycha* have been described, and all but eight are African. This part, the first step of a proposed revision covering the entire genus, includes the natural faunistic unit found south of a line across the continent along the border between Angola and Southwest Africa and continuing eastward along the Zambezi River. Very few species

occur on both sides of this line. This is the first comprehensive paper on the *Schizonycha* since Péringuey published a similar but much less extensive paper in 1904.

Pope combines the genus *Atys* Reiche with *Schizonycha* to list 107 species described from southern Africa. In the present paper he points out 22 cases of synonymy and five cases of preoccupied names. Nineteen new species and the five new names bring the total number of valid species to 117.

A complete history of the genus is given. *Scarabaeus globata* Fabricius (1781) is selected as the type of the genus *Schizonycha* Dejean (1833), and discussion of and reasons for the selection are presented. The taxonomic position of the genus and its relationship to other genera are covered adequately. The paucity of information on the biology and habits of the group is pointed out, with a review of what little is known.

Perhaps the most valuable part of the revision is the carefully prepared, easily followed key to the species involved. It is very full, but it is clear and understandable even though it includes 125 couplets covering 15 pages. For each species the following information is given: pertinent references, description of both sexes, type locality, location of type, distribution, and number of specimens seen. Five plates, illustrating adults and diagnostic characters other than genitalia, plus nine illustrations of genitalia, complete the book.

O. L. CARTWRIGHT
Museum of Natural History, Smithsonian Institution

Ecology of the Peregrine and Gyrfalcon Populations in Alaska. *University of California Publications in Zoölogy*, vol. 63, No. 3, pp. 151–290. Tom J. Cade. University of California Press, Berkeley, 1960. Illus. + plates. $2.50.

This study of two closely related raptors in an environment "biotically simple, geologically young, and still in a state of active surficial change" began as a study intended to supplement and extend analyses already made of peregrine populations in North America, the British Isles, the Baltic Sea region, the Soviet Union, and Greenland. The author found that in Alaska the gyrfalcon is an important part of the peregrine's ecology, so the study became comparative; his report includes sections on the distribution, abundance, and breeding biology of the two species in Alaska; it also includes discussions of the nesting cliff as an "ecological magnet," the importance of a strong pair bond, tradition as a factor linking generations to the same cliff, the significance of sexual dimorphism in falcons, and peregrine versus gyrfalcon competition. Cade shows clearly that further study of the gyrfalcon is sorely needed, an observation that applies, I hasten to add, not only to Alaska but to all parts of the species' range.

The gyrfalcon is the world's largest true falcon, and it is the only true falcon that breeds exclusively in the far north. It is highly polymorphic. Its polymorphism varies geographically both in kind and in degree, mixed broods of white and gray birds being the rule in some areas, most birds being white in northern Greenland, all breeding birds being gray in Iceland, some birds being very dark in the Canadian Arctic Archipelago and in Labrador. Geographical races have been described, but none of them are strongly characterized. The species is sexually dimorphic, strikingly so in size, the females being much larger than the males, but less strikingly so in color, the males being paler than the females, as a rule. Cade considers the gyrfalcon "the counterpart of a basic stock which has always been associated with landscapes of open expanse such as prairies, steppes, and deserts, and which is adapted for catching both birds and mammals (and also reptiles) pursued on or near the ground." The species breeds circumboreally—northward to 82°N. in Greenland, southward to 60°N. in Greenland, and even somewhat farther southward in the Komandorski Islands, Labrador, the Altai Mountains, and around the base of the Alaska Peninsula.

The peregrine, the third-largest of the true falcons, is also sexually dimorphic in size, females being much larger than males. The species is a bird of compact plumage "adapted primarily for the pursuit of flying quarry." Unlike the gyrfalcon, the peregrine is virtually world-ranging, and it is highly polytypic, 22 geographical races being recognized by some taxonomists. Possibly as a result of an ameliorating arctic climate within recent times, it now breeds northward to 75° to 78° N. Birds which breed in the far north are strongly migratory. An important (but in my opinion not wholly valid) point made by the author is that the arctic peregrine's reproductive cycle is determined to a considerable extent by the migrations of prey species, while that of the gyrfalcon is not.

The breeding ranges of these two large falcons overlap to some extent. The peregrine is not known to breed northward to 82°, but in some areas at the southern limits of the gyrfalcon's breeding range, the peregrine may breed in greater numbers than it does in any other part of the world. The overlap is more apparent than real, and only in certain restricted areas are the two species truly sympatric. Thus, while the gyrfalcon inhabits Iceland, the peregrine does not; the common falcon of northern Greenland is the gyrfalcon, of southern Greenland the peregrine; in the Aleutians there are many breeding peregrines but no gyrfalcons, while on the mainland coast from the base of the Alaska Peninsula to Point Hope, gyrfalcons "maintain maximum densities" but peregrines are rare.

In Alaska the gyrfalcon breeds in foothill tundra and arctic alpine areas (frequently in localities above 2500 feet elevation and far from water) and on coasts and islands in the Bering Sea region. The peregrine, on the other hand, invariably breeds near water, either on the outer coast or along a river, and at elevations below 2500 feet. "The principal areas of actual overlap . . . are the foothills of the arctic slope and the coast and hinterland of the Arctic Ocean from Kotzebue Sound to Cape Lisburne."

Some sort of cliff is required by both species for nesting. In general, cliffs used by gyrfalcons are more "accessible" than cliffs used by arctic peregrines. Gyrfalcons have fewer nesting sites to choose from since they must find one that is free of snow at the laying season. Gyrfalcons start nesting about a month ahead of the peregrines and, therefore, take possession of some cliffs that might, were it not for the gyrfalcons, be used by peregrines. Nesting cliffs are rarely very close together, and no cliff is occupied by both peregrines and gyrfalcons or by more than one pair of either species.

Choice and defense of the nesting cliff are an important part of the reproductive cycle. The cliff must be close to an adequate supply of food. Since gyrfalcons prey heavily on ground squirrels in Alaska, especially in the

Alaska Range, it occurs to me that the gyrfalcon's laying season, which begins in April, may take place about the time the ground squirrels emerge from hibernation, a predator-prey relationship not discussed in this paper. Wilber and Musacchia [*J. Mammalogy* **31**, 307 (1950)] state that *Citellus barrowensis* comes out of hibernation "about the middle or end of April," and my friend W. O. Pruitt, Jr., informs me that he saw an active, adult ground squirrel in the Cape Thompson region of Alaska as early as 19 April 1960. The comparatively euryphagous peregrine, which can and does subsist on mammals as well as on transient birds, has no trouble obtaining food when its own laying season starts, if its nesting cliff is near water. On treeless Baffin Island peregrines frequently take lemmings when these rodents are numerous; but peregrines are highly prone to take flying prey, and robins, jays, waxwings, and the like expose themselves to capture when they fly across rivers in wooded parts of Alaska.

I call attention to the need for proof that the gyrfalcon is truly sedentary at high latitudes. Available data indicate that the species is regularly migratory, less so than the peregrine in that it rarely moves very far south of the arctic, but definitely migratory within latitudinal limits. White ptarmigan feathers found at plucking spots well north of the Arctic Circle (see page 204) are not proof of the gyrfalcon's winter residence, for cock ptarmigan wear white plumage well into summer. The Kenai area, in which gyrfalcons are said to be commoner in winter than at any other season, is well south of the Arctic Circle. There are very few (if any) valid records of gyrfalcons being seen or taken at really high latitudes in the dead of winter. Gyrfalcons are known to follow the ptarmigans south during the period when the nesting grounds of both gyrfalcons and ptarmigans are in winter darkness. To this extent, I submit, the gyrfalcon and peregrine are equally dependent upon migratory species.

The discussion of the nesting cliff as an "ecological magnet" is thought-provoking. Cade found that in Alaska "very high cliffs seem to be avoided by peregrines," nesting birds frequently being found on a low bluff only a few hundred yards from an unoccupied cliff with face 300 to 500 feet high. "Such a lack of preference for cliffs is especially conspicuous along the Colville River, but it seems to be generally true over much of Alaska." Cade is convinced that the "first-class aerie" is not so much a matter of cliff dimensions, exposure, and the like, as of occupation by a pair of "effective breeders"—that is by "a pair that usually is able to fledge one or more young each year because the mates have established all the social adjustments required for a strong pair pond. Such pairs can withstand a great deal of molestation by human beings and other predators, regardless of the physical characteristics of their aeries . . ." Breeding pairs of peregrines observed by Cade in Alaska were, almost without exception, composed of fully mature birds.

Cade concludes that the gyrfalcon is the "dominant competitor" in Alaska because of its greater size and strength and because its early nesting "gives it first chance to settle on the available cliffs," but that the peregrine is "numerically more successful" over most of its Alaska range because it readily adapts itself to changing climatic conditions, is less exacting than the gyrfalcon in choice of nesting cliffs, has no difficulty in obtaining plenty of food all summer long, and escapes the arctic winter by migration.

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New Books

Biological and Medical Sciences

The Lower Animals. Living invertebrates of the world. Ralph Buchsbaum and Lorus J. Milne. Doubleday, Garden City, N.Y., 1960. $12.50. This volume ranges from the microscopic radiolarians to the giant squids, from spiders on high mountains to sea cucumbers. The illustrations include 292 photographs (many of them in color) and 23 drawings.

The Memoirs of Ray Lyman Wilbur. 1875–1949. Edgar Eugene Robinson and Paul Carrol Edwards, Eds. Stanford Univ. Press, Stanford, Calif., 1960. 703 pp. $10.

The World of Amphibians and Reptiles. Robert Mertens. Translated by H. W. Parker. McGraw-Hill, New York, 1960. 207 pp. Illus.

General

Common Sense about Africa, Anthony Sampson, 175 pp.; **Common Sense about the Arab World**, Erskine B. Childers, 192 pp.; **Common Sense about China**, Guy Wint, 176 pp.; **Common Sense about Russia**, Robert Conquest, 175 pp. Macmillan, New York, 1960. $2.95 each. "The aim of this series is implicit in its title. . . . The authors have been asked . . . to assume no special knowledge of the subject on the part of their readers . . . to write in a manner immediately intelligible to [anyone] of average education . . . and . . . to be as objective as . . . possible."

Can We End the Cold War? A study in American foreign policy. Leo Perla. Macmillan, New York, 1960. 251 pp. $4.50.

China Crosses the Yalu. The decision to enter the Korean War. Allen S. Whiting. Macmillan, New York, 1960. 235 pp. $7.50.

The Squeeze. Cities without space. Edward Higbee. Morrow, New York, 1960. 367 pp. $5.95.

Wild Life in an African Territory. A study made for the Game and Tsetse Control Department of Northern Rhodesia. F. Fraser Darling. Oxford Univ. Press, New York, 1960. 168 pp. $4.

Reference and Bibliography

The International Dictionary of Applied Mathematics. W. F. Freiberger, Editor-in-Chief. Van Nostrand, Princeton, N.J., 1960. 1181 pp. Illus. $25. More than 8000 entries, prepared by 33 contributing editors, define terms and describe methods in the applications of mathematics to 31 fields of physical science and engineering. The volume contains a group of four foreign language indexes that alphabetically list the French, German, Russian, and Spanish equivalents of the terms defined and give their English equivalents. Typical entries are: "*ABAMPERE.* The *cgs electromagnetic unit* of current. It is that current which, when flowing in straight parallel wires 1 cm apart in free space, will produce a force of 2 dynes per cm length on each wire. One abampere is ten absolute amperes. (See *electromagnetic units.*)" "*ATOMIC ORBITAL.* See *orbital.*" "*GEODESIC COORDINATES (PARAMETERS) FOR A SURFACE.* Parameters u, v such that the curves $v =$ constant are a singly-infinite family of geodesics and the curves $u =$ constant are the *geodesic parallels* orthogonal to them." "*MACAULEY METHOD.* A method of simplifying the double integration procedure for calculating the deflections of beams of uniform cross section when the applied loading is discontinuous. Two constants of integration only are introduced. Junction conditions at points of discontinuity of loading $x = a$ are satisfied by integrating $x—a$ as a unit, and by extending all distributed loads to the right-hand end of the beam, introducing negative loads as needed." Entries vary in length from a line to more than a page, and many are illustrated.

Nuclear Reactors. Bibliographical series, No. 2. International Atomic Energy Agency, Vienna, Austria, 1960 (order from National Agency for International Publications, New York). 716 pp. $5. The 4118 items in this bibliography cover the relevant literature in English, French, Russian, German, Italian, Japanese, and certain other languages, published from 1947 to 1959. All items are classified by subject (ten categories) and are listed alphabetically, by title of the abstracted paper, within each category.

Reports

Evidence That Retinal Flicker Is Not a Necessary Condition of Imprinting

Abstract. Thirty-six chicks were exposed to motionless geometric objects during the third, fourth, and fifth days of life to test the contention that retinal flicker is an irreducible condition of imprinting. The results indicated that the only necessary condition for a positive effect is that the model should be prominently displayed in the animal's visual environment.

Not the least disconcerting aspect of the recent revival of interest in imprinting is the various attempts by psychologists to elaborate precise laws from minimal evidence. Thus Hess has proposed a law that the strength of imprinting is equal to the logarithm of the effort expended by the animal in reaching the imprinting model (*1*), although the sizes of the samples used in the experiments from which this law was deduced were not reported (*2*). On the basis of more fully documented data, James has suggested that retinal flicker is not only a critical factor in the phenomenon of imprinting but that it should be considered as an unconditioned stimulus for the following response. In his experiment, chicks were exposed to a novel object in the vicinity of a flickering light source from the third day of age. These animals showed an attachment to the object not paralleled by a control group exposed to the same object in the vicinity of a constant light source. It is to be noted that, with the two light sources opposed, the chicks preferred the flickering light and did not frequent the area of the constant light which, for the control animals, contained the imprinting model (*3*).

In a reformulation of William James and Konrad Lorenz's historic conception of filial attachment, Moltz has raised to the near status of law the conclusion that retinal flicker is an irreducible condition of imprinting (*4*). If true, such a law would clearly be a matter of great theoretical importance. The present experiment testifies that such a law has no basis in fact.

Three groups of White Rock chicks were exposed to motionless black geometric objects for 24-hour periods; half of each group were exposed to a circle 3½ inches in diameter and half to a triangle 4 inches on a side; both objects were ¾ inch thick. The objects were visible through the glass walls of isolation booths (*5*). Each group was composed of 12 subjects, with the first group being exposed on the third day of age, the second group on the fourth day of age, and the third group on the fifth day of age. Each chick was hatched in an isolation compartment and, except for exposure and test periods, remained in visual isolation throughout the experiment. The incandescent light sources were powered by 60 cy/sec current, a frequency which James' data do not suggest is low enough to induce flicker in the chick.

At the end of their respective 24-hour exposure periods, the chicks were tested for their tendency to discriminate the familiar object from the other (unfamiliar) object. The test box was divided into three compartments in its longest dimension; the center compartment held a movable platform, connected by microswitches to electric timers, upon which a subject was placed; one end compartment held a circle model while the other end compartment held a triangle model; the compartments were separated by glass partitions. As in the exposure situation, the models were motionless. The test period was 15 minutes; final scores were expressed as time spent near the familiar model minus time spent near the unfamiliar model.

A statistical assessment of the data with parametric methods yielded the following results. The day-3 group mean of 3.65 minutes near the familiar model approached but did not attain significance at the .05 level with a two-tailed *t*-test against a null hypothesis of zero; the day-4 group mean of 5.77 minutes was significant at less than the .05 level; and the day-5 group mean of 7.83 minutes was significant at less than the .01 level. A between-within analysis of variance gave an *F* slightly less than 1, suggesting that the means were from a homogeneous population. The relative preferences for the familiar over the unfamiliar models are given in Fig. 1.

These results are unequivocal. Chicks will form an attachment to motionless objects even when the objects are not in the vicinity of a flickering light. In this experiment, however, the models were not an unobtrusive part of the environment. Against a background of light gray, the black geometric objects dominated the visual field. Probably anything that will make an object stand out in the chick's visual environment will be a factor in imprinting. Motion would thus be a factor, but it is not an irreducible condition, and neither is retinal flicker; nor is there any obvious merit in calling either motion or flicker an "unconditioned stimulus" for imprinting when the term has a definite meaning in the well-defined phenomenon of classical conditioning but is

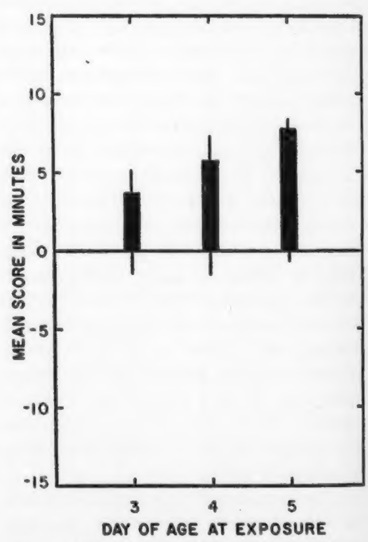

Fig. 1. Time spent before familiar (positive numbers) and unfamiliar (negative numbers) objects as a function of day of exposure. Bars indicate relative mean time and lines indicate absolute mean time either positive or negative. The figure could be thought of as a pictorial representation of the test apparatus platform with zero as the pivotal line.

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* **125**, 16 (1957)].

merely misleading in reference to imprinting.

It seems likely that James failed to obtain an effect with his control animals simply because the animals did not frequent the area in which the imprinting object was placed (*3*).

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29 August 1960

Ribonuclease of Euglena gracilis

Abstract. An enzyme in extracts of *Euglena gracilis* splits both purine and pyrimidine internucleotide bonds of ribonucleic acid. Its *p*H optimum is at 4.5; it is very heat-labile and is rather insensitive to inhibition by metal ions or sulfhydryl group reagents. A partial purification of the enzyme is described.

Recently, several enzymes of the protistan *Euglena gracilis* were examined in connection with other metabolic studies. Because of the special taxonomic position of this type of organism, it seemed of interest to compare the properties of some of these enzymes with those of similar enzymes from plant and animal sources. This report deals with the isolation, partial purification, and properties of a ribonuclease from *E. gracilis*. Ribonucleases from a wide variety of tissues and organisms have been described in the literature (*1, 2*).

Mass culture and harvesting of *Euglena*, as well as the extraction of the enzyme, were carried out as previously described (*3*). The ribonuclease assay was a modification of a published spectrophotometric procedure in which the ultraviolet-absorbing material remaining in solution, when the undegraded and partially degraded ribonucleic acid is precipitated from the reaction mixture by uranium acetate at *p*H 3.0, is determined at 260 mμ (*4*). The incubation was carried out at a *p*H of 4.5 in the presence of 0.05*M* acetate buffer for a period of 2 hours with 0.25 ml of the enzyme extracts or corresponding amounts of the purified fractions. The symbol Δ^{260}, which is used to express the enzymatic activity in Fig. 1 and throughout the text, represents the difference between the absorption in the experimental tubes and controls at 260 mμ.

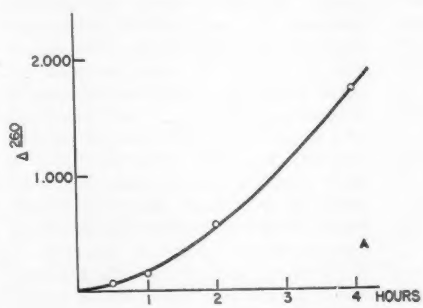
The time course of the degradation of ribonucleic acid by the *Euglena* enzyme is shown in Fig. 1*A*. As shown in Fig. 1*B*, the enzyme has a very sharp optimum of activity at *p*H 4.5. This value is at the lower end of the range of *p*H optima (4.5 to 5.5) reported for a number of plant ribonucleases, while the enzymes of animal origin tend to have a higher optimal *p*H (*2, 5*). Unlike a number of other ribonucleases, the *Euglena* enzyme was found to be extremely heat-labile. When the enzyme extract was heated to 68°C at a *p*H of 4.6 in the presence of 0.05*M* acetate buffer, all activity was lost within 2 minutes. As in the case of pancreatic ribonuclease (*6*), the activity of the *Euglena* enzyme increased with increasing ionic strength, with an optimum at approximately 0.5*M* sodium chloride (Fig. 1*C*). Metal ions, which have been shown to inhibit pancreatic ribonuclease (*7*), were found to affect the enzyme from *Euglena* at rather high concentrations only (Table 1). The sulfhydryl group reagents *o*-iodosobenzoate and *p*-chloromercuribenzoate, which were tested at concentrations from $10^{-5}M$ $10^{-3}M$, were without effect, except for *p*-chloromercuribenzoate, which had a somewhat inhibiting effect at the highest concentration.

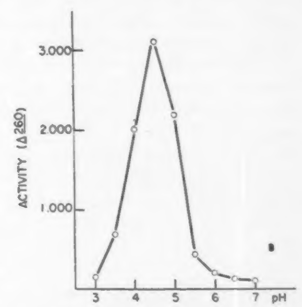
An approximately 15-fold purification of the enzyme was achieved by two ammonium sulfate fractionations; in the first, at *p*H 8.5, the protein precipitating between 38 and 53 percent of saturation in ammonium sulfate was collected; in the second, protein precipitating at *p*H 7.0, between 39 and 51 percent of saturation. These fractionations were followed by the removal of inactive protein by adsorption on calcium phosphate gel (*8*) and a final ammonium sulfate precipitation, at *p*H 7.0, between 39 to 51 percent of saturation, to concentrate the enzyme solution. While the over-all yield in enzymatic activity by this procedure was only of the order of 20 percent, an essentially phosphomonoesterase-free ribonuclease was obtained.

Table 1. Inhibition of *Euglena* ribonuclease by various metal ions at four concentrations. Assay as in text.

Cation	Inhibition (%)			
	$10^{-5}M$	$10^{-4}M$	$10^{-3}M$	$10^{-2}M$
Fe^{+++}	16	20	65	100
Cu^{++}	6	11	40	76
Zn^{++}	19	18	23	96
Pb^{++}	17	43	48	81

The specificity of this enzyme preparation was examined by two methods. In the first, its activity against ribonucleic acid was compared to its activity against the so-called ribonucleic acid "core." This "core" is obtained by exhaustive digestion of ribonucleic acid by pancreatic ribonuclease, and it is resistant to further degradation by this enzyme (*9*). It has been shown to consist of a mixture of oligonucleotides containing mainly purine bases (*9*). When *Euglena* ribonuclease was allowed to act on this "core" and on undegraded ribonucleic acid at *p*H 4.5, values of 0.720 and 2.040, respectively, were ob-





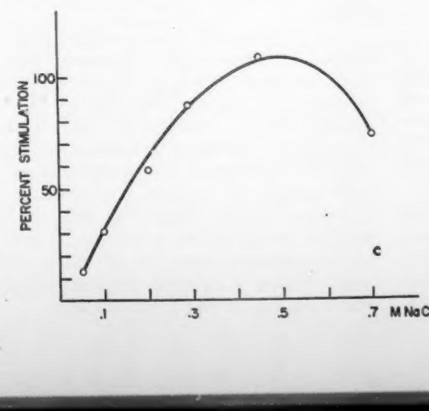


Fig. 1. *A*, Time course of the degradation of ribonucleic acid by *Euglena* ribonuclease. *B*, Optimal *p*H of *Euglena* ribonuclease. The substrate was adjusted to the desired *p*H values with dilute sodium hydroxide or hydrochloric acid; a Radiometer 22 *p*H meter was used. *C*, Effect of sodium chloride concentration on the activity of *Euglena* ribonuclease. Assays as in text.

tained for Δ^{260}, while pancreatic ribonuclease (*10*) at *p*H 7.3 gave a Δ^{260} of 0.930 with ribonucleic acid and of 0.000 with the "core." Unlike the pancreatic enzyme, the *Euglena* ribonuclease therefore was capable of further degrading the "core"—an indication that it does not share the specificity of pancreatic ribonuclease for pyrimidine internucleotide bonds. This was confirmed by experiments in which the enzymes were allowed to act on polyadenylic and polyuridylic acid (*11*) and in which the reaction products were analyzed by paper chromatography. Both polymers were degraded by the enzyme from *Euglena,* while pancreatic ribonuclease attacked only the polyuridylic acid (*12*).

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10. The pancreatic ribonuclease was obtained from the Worthington Biochemical Corp., Freehold, N.J.
11. We are very grateful to Dr. Roland F. Beers, Jr., Children's Hospital, Baltimore, Md., for preparing the polyadenylic and polyuridylic acid.
12. We wish to thank Dr. M. K. Bach of the research department, Union Carbide Chemicals Co., for advice and help in growing the *Euglena.*
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2 August 1960

Effect of Reserpine on Ventricular Escape

Abstract. Catecholamine depletion by reserpine diminishes the tendency of the ventricle to escape from vagal suppression. Neither spinal section nor adrenalectomy enhances the reserpine effect. Norepinephrine restores the characteristic occurrence of ventricle escape during vagal stimulation.

Krayer and his co-workers (*1*) have described the importance of catecholamines to the rhythmicity of the sinus pacemaker, and Roberts and Modell (*2*) have shown that catecholamine activity is even more important to the rhythmicity of the ventricular pacemaker. It has been recently indicated that an adrenergic mechanism may play a role in the phenomenon of vagal escape (*3*). If catecholamines are important to the intrinsic rhythmicity of the ventricle, then ventricular escape from vagal control should be influenced by catecholamine depletion. This report (*4*) describes experiments designed to explore this relationship. Reserpine was used to deplete the amines.

Table 1. The effect of reserpine on ventricular escape during vagal stimulation. S.E., standard error.

Procedure	No. of animals	Av. slowest sinus rate (induced by vagal stimulation) (beats/min. ± S.E.)	Av. ventricular escape rate* beat/min ± S.E.	Incidence of asystole†	Av. duration of asystole (sec ± S.E.)
		Anesthetized animals			
Control	15	49 ± 8	64 ± 8	2/15	7
Reserpine-treated	14	14 ± 5	28 ± 7‡	11/14	17 ± 2
		Animals with spinal-cord section			
Control	14	60 ± 6	66 ± 5	0/14	0
Reserpine-treated	4	7 ± 2	20 ± 11	4/4	14 ± 4

* See text for explanation. † Periods longer than 5 seconds. ‡ Based on 11 animals, since three developed only sinus escape.

In cats with the spinal cord sectioned at C1 or in cats anesthetized with Dial urethane (0.6 to 0.7 ml/kg), the right vagus nerve was stimulated. With appropriate vagal stimulation, the sinus rate may be slowed sufficiently to permit ventricular escape—that is, there is an unmasking of ventricular rhythmicity through the removal of sinus dominance. In each experiment the minimal intensity of vagal stimulation which would permit ventricular escape was used. Therefore, while the stimulus parameters varied, animals were compared at equivalent stimulus responses. Pulses of 6 to 14 volts, frequency of 10 to 40 cy/sec, and pulse duration of 0.1 msec applied for at least 20 seconds (*5*) were usually sufficient to produce ventricular escape. Reserpine (0.5 to 10.0 mg/kg) was injected intravenously 24 to 50 hours before the experiment. Since there was no significant difference in the effects of reserpine in the dose range employed, the results at all dose levels were pooled and averaged. The data are summarized in Table 1.

In 15 untreated, anesthetized animals, when the sinus rate decreased during vagal stimulation to an average of 49 beats per minute, the rate of ventricular escape averaged 64 beats per minute and stabilized at an average of 75 beats per minute. Untreated animals with spinal-cord section responded in a similar manner, indicating that ventricular escape is not primarily related to sympathetic tone. In all cases, a sinus rhythm reappeared promptly after the cessation of vagal stimulation.

In animals treated with reserpine, ventricular escape still occurred, but there was a striking difference in the sinus rate at which this escape from vagal control appeared. Furthermore, ventricular rate after escape from vagal control also differed greatly from the comparable ventricular rates in the untreated animals. In 14 anesthetized animals, when the sinus rate was slowed by vagal stimulation to an average of 14 beats per minute, the independent ventricular rate averaged 28 beats per minute. These rates are significantly lower than those of the controls ($p < .01$). There was a similar response in four reserpine-treated animals with spinal-cord section. During vagal stimulation, asystolic periods of more than 5 seconds duration developed in only two of 29 untreated animals; such periods occurred in 15 of 18 reserpine-treated animals. In addition, the duration of asystole was considerably greater in the reserpine-treated animals (Table 1). The lower independent ventricular rate and the longer period of asystole after reserpine treatment indicate that the effect of reserpine on the ventricle is a consequence of an altered ventricular rhythmicity.

The appearance of ventricular escape during asystole suggests other factors not influenced by reserpine. In all reserpine-treated animals with spinal-cord section and in two reserpine-treated anesthetized animals, ventricular escape during asystole developed with the onset of convulsions. Thus, it seemed possible that such concomitants of anoxia as the liberation of potassium or the mobilization of cardiac catecholamine stores not depleted by reserpine (*6*) provoked ventricular escape. Other sources of catecholamines probably did not play a role, since bilateral adrenalectomy after reserpine treatment (in one anesthetized animal and in two animals with spinal-cord section) did not further diminish the ability of the ventricle to escape from vagal suppression.

In 12 animals treated with reserpine the administration of norepinephrine prevented, during vagal stimulation, the

development of asystolic periods of more than 5 seconds' duration. The vagus was stimulated periodically during an infusion of 0.1 to 1 μg of norepinephrine per kilogram per minute. After 5 to 10 minutes, vagal stimulation permitted ventricular escape with much less slowing of the sinus rate. The reversal of the reserpine effect by norepinephrine implies that the effect of reserpine to reduce ventricular rhythmicity is the result of catecholamine depletion.

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5 October 1960

Crystal Structure Refinement of Reedmergnerite, the Boron Analog of Albite

Abstract. Ordering of boron in a feldspar crystallographic site $T_1(0)$ has been found in reedmergnerite, which has silicon-oxygen and sodium-oxygen distances comparable to those in isostructural low albite. If a simple ionic model is assumed, calculated bond strengths yield a considerable charge imbalance in reedmergnerite, an indication of the inadequacy of the model with respect to these complex structures and of the speculative nature of conclusions based on such a model.

Recent conclusions important to the interpretation of the mineralogy and petrology of alkali feldspars have been presented by Ferguson (*1*). Evidence supporting the new theory is taken in part from the results of crystal-structure analyses of low and high albite (*2*) as to (Al, Si)-ordering in tetrahedral sites T_1 (0), T_1 (*m*), T_2 (0), and T_2 (*m*), and from the resulting charge balance calculated for these sites when a simple ionic model is assumed. Determination by x-ray diffraction methods of (Al, Si)-distribution in feldspar crystals must necessarily be indirect because of the near equivalence in x-ray scattering power of aluminum and silicon. A recently described mineral, reedmergnerite (*3*), $NaBSi_3O_8$, is isostructural with albite, $NaAlSi_3O_8$, and the elements boron and silicon can readily be distinguished by x-ray techniques. Furthermore, aluminum and boron have many chemical and structural similarities in crystals, both elements occurring coordinated by a tetrahedron of oxygens, with boron-oxygen distances of 1.46 to 1.48 A (*4*) and aluminum-oxygen distances of 1.75 to 1.79 A (*5*). It seemed probable that comparison of albite and reedmergnerite structures would help to clarify the (Al, Si)-distribution problem and provide additional information about charge balance assumptions. Accordingly, a detailed crystal-structure investigation of reedmergnerite has been completed, in which we started with the known low albite parameters (*2*).

Thirteen cycles of least-squares analysis of 2753 three-dimensional data for reedmergnerite have been carried out on a Burroughs 220 digital computer; the full matrix associated with the normal equations was used. A residual factor

$$R = \Sigma \,||F_{\text{obs.}}| - |F_{\text{calc.}}|| / \Sigma \,|F_{\text{obs.}}|$$

of 11 percent has been obtained, excluding data recorded as zero. Reedmergnerite contains the typical feldspar framework found in low albite (*2*); the refinement shows that boron is wholly contained in site T_1 (0), and that the framework is distorted as compared to that in albite, so that the smaller boron-oxygen tetrahedra can be accommodated. The resultant shrinkage in framework accounts for an average 4-percent reduction in dimensions of the reedmergnerite cell as compared with those of the albite cell (*3*). The silicon-oxygen distances in reedmergnerite (Table 1) compare so closely with those reported for low albite (*2*) that considerable doubt is cast on the validity of (Al, Si) assignment from small variations in these bond distances, according to the relationship proposed by Smith (*5*) and used in the study of albite (*2*).

Table 1. Some interatomic distances for reedmergnerite and low albite (*2*).

	Interatomic distances (A)	
	Reedmergnerite (all ± 0.01 A)	Low albite
	$T_1(0)$ tetrahedron	
(B or Al)-$O_A(1)$	1.47_3	1.76_3
(B or Al)-$O_B(0)$	1.48_4	1.70_2
(B or Al)-$O_C(0)$	1.44_6	1.76_2
(B or Al)-$O_D(0)$	1.47_3	1.74_4
Av.	1.46_8	1.74_3
	$T_1(m)$ tetrahedron	
Si-$O_A(1)$	1.58_9	1.59_6
Si-$O_B(m)$	1.60_6	1.62_6
Si-$O_C(m)$	1.60_2	1.55_3
Si-$O_D(m)$	1.62_1	1.58_3
Av.	1.60_3	1.59_0
	$T_2(0)$ tetrahedron	
Si-$O_A(2)$	1.62_7	1.61_8
Si-$O_B(0)$	1.57_6	1.62_7
Si-$O_C(m)$	1.63_0	1.64_9
Si-$O_D(m)$	1.62_0	1.64_9
Av.	1.61_3	1.63_6
	$T_2(m)$ tetrahedron	
Si-$O_A(2)$	1.65_0	1.64_0
Si-$O_B(m)$	1.61_4	1.59_7
Si-$O_C(0)$	1.61_8	1.61_8
Si-$O_D(0)$	1.60_9	1.61_1
Av.	1.62_3	1.61_6
	Oxygen-Na	
$O_A(1)$	2.48_1, 2.50_3	2.61_5, 2.68_1
$O_A(2)$	2.39_2	2.36_3
$O_B(0)$	2.40_6	2.46_0
$O_C(0)$	(3.44_1)	2.88_9
$O_C(m)$	2.84_4	(3.24_7)
$O_D(0)$	2.37_8	2.46_5
$O_D(m)$	2.85_2	(2.99_7)

The sodium atoms in reedmergnerite are located in the cavities within the feldspar framework. Anisotropic temperature motion of the sodium atoms has not yet been fully investigated, but the isotropic temperature factor *B* is 1.23 A^2, in marked contrast to the maximum *B* of 0.78 A^2 found for the other atoms in the structure. The coordination of oxygen atoms about sodium in reedmergnerite is comparable to that found in albite for the five closest oxygens (Table 1), but some

Table 2. Bond strengths contributed by (B or Al)$^{3+}$, Si^{4+} and Na^+ to O^{2-} atoms in tetrahedral groups of reedmergnerite and low albite (*2*). (*a*) $T_1(0)$=B (reedmergnerite), Al (low albite), remainder = Si; Na coordinated by five closest oxygens (reedmergnerite, Table 1), by six closest oxygens (low albite, Table 1). (*b*) $T_1(0)$=B (reedmergnerite), Al (low albite), remainder = Si; Na coordinated by seven oxygens (Table 1). (*c*) Al-Si distribution taken as follows: $T_1(0)$ = 0.72 Al, $T_1(m)$ = Si, $T_2(0)$ = 0.20 Al, $T_2(m)$ = 0.09 Al, remainders = Si; Na coordinated by six oxygens (Table 1). (*d*) Al-Si distribution as in (*c*); Na coordinated by seven oxygens (Table 1).

Tetrahedral site	Bond strength					
	Reedmergnerite		Low albite			
	(*a*)	(*b*)	(*a*)	(*b*)	(*c*)	(*d*)
$T_1(0)$	7.80	7.56	7.83	7.71	8.02	7.90
$T_1(m)$	8.15	8.31	8.08	8.18	8.03	8.13
$T_2(0)$	8.15	8.31	8.08	8.18	7.93	8.03
$T_2(m)$	7.90	7.78	8.00	7.93	8.00	7.93
$\Sigma\|\Delta\|$	0.60	1.28	0.33	0.72	0.12	0.33

changes occur among oxygens more distant than 2.6 A from sodium. These changes require that sodium in reedmergnerite be considered as either five- or sevenfold coordinated, in contrast to the sixfold coordination assigned to sodium in low albite (*2*). When bond strengths to the oxygens in reedmergnerite are calculated over each tetrahedral site, on the basis of a simple ionic model, and compared with those so determined for albite (*2*), a charge imbalance is found in reedmergnerite (Table 2) that at best is almost double any found for albite. In our opinion such calculations serve merely to underline the inadequacy of the ionic model in treating the complex feldspar structures. This study strongly suggests that any new theory dependent on results from such a model should be considered speculative until more experimental evidence becomes available (*6*).

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30 August 1960

Detection of Boundary Films

Abstract. Results, obtained with a photoelectric refractometer and sucrose solutions, indicate that a concentrated surface layer rapidly builds up when sucrose solutions are allowed to stand under conditions where evaporation can occur from the surface. The phenomenon is similar to the formation of a cool boundary film which has recently been shown to occur on the surface of the ocean.

Ewing and McAlister have recently reported experiments showing the existence of a cool boundary film on the surface of evaporating water (*1*). We have observed a similar phenomenon during investigations carried out to develop a photoelectric refractometer for use in the sugar industry. The effect is particularly marked when the U-bend type of refractometer first described by Karrer and Orr (*2*) is used. This consists of a U-bend of solid glass rod down one limb of which parallel light is shone. The intensity of the light emerging from the other limb, which is easily measured photoelectrically, is dependent on the refractive index of the medium in which the curved part of the U-bend is immersed.

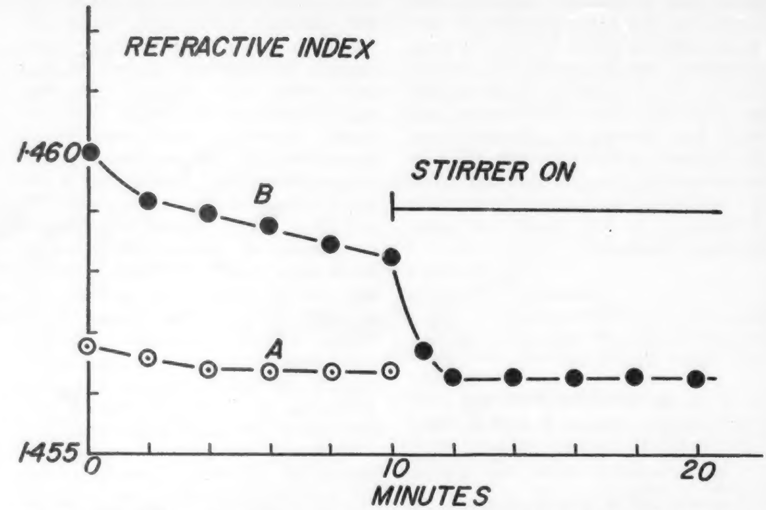

Fig. 1. Graphs of refractive index, as determined by the U-bend photoelectric refractometer, against time. Curve *A* was obtained when the U-bend was introduced into a freshly stirred sucrose solution; curve *B* was obtained when the U-bend was introduced into the sucrose solution which had been allowed to stand for 1 minute. After 11 minutes, this solution was stirred with an ordinary laboratory-type stirrer.

Typical results are shown in Fig. 1, which is a graph of the refractive index indicated by the photocell output against time. These particular results were obtained with a rod 8 mm in diameter bent into a U with a radius of 2.5 cm at the curved end. The solution used was a pure, aqueous sucrose solution of concentration 67 percent by weight; the measurements were made in a darkened room at a temperature of 24°C and a relative humidity of 75 percent.

Curve A shows that when the dry U-bend is immersed in the freshly stirred solution, the refractive index is almost constant. If, however, the sucrose solution is allowed to stand for 1 minute before the U-bend is introduced (curve B), the indicated refractive index is initially higher but begins to drift downwards; if the solution is then stirred, the indicated refractive index drops rapidly to a constant value equal to that found in a freshly stirred solution.

The explanation of these effects appears to be that when sucrose solutions are allowed to stand under conditions where surface evaporation can occur, a boundary film of concentrated solution builds up; this film adheres to the U-bend when it is passed through the surface but can be dispersed by mild agitation. This explanation is similar to that given by Ewing and McAlister for their experiments, although we have postulated a concentration rather than a temperature gradient; to ascribe the phenomenon to temperature effects alone would require the surface film to be some 20°C cooler than the bulk of the liquid.

The effect is so marked with sucrose solutions probably because the diffusion constant for sucrose solutions diminishes rapidly at high concentrations (*3*). In agreement with this, the effect is small at moderate concentrations of sucrose but is larger than that shown in Fig. 1 when molasses is used. It is of some interest that the boundary film can build up so quickly when a sugar solution is handled in the atmosphere; the need for care in carrying out precision refractometry with concentrated sugar products is clear.

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5 July 1960

In vitro Organization of Single Beating Rat Heart Cells into Beating Fibers

Abstract. Single, separate rat-heart cells in culture beat at different rates. When they grow into physical contact the beating becomes synchronous. Increase in cell number leads to the formation of beating, fiber-like masses. It appears that direct physical contact is necessary for attainment of synchronous contractions.

A previous report (*1*) from this laboratory concerned the isolation of single beating cells from the hearts of young rats (2 days to 6 weeks old). Several interesting phenomena have been observed as these single cells developed into confluent sheets. The techniques were essentially those previously reported (*1, 2*). Further investigation has led to experiments in which essentially all of the single cells attached to the glass are beating. In the early stages of the culture, these cells are separate from each other and beat at independent rates, varying from slow to fast and from intermittent to regular beats. The rate varies in general from about 30 to 80 beats per minute. Figure 1 is a photomicrograph of independent cells, with different rates of beating. In the single separate cell cultures, from 2 to 10 percent of the cells beat.

As these cells spread out and increase in diameter, they become very irregular in outline and put out long protoplasmic extensions. Eventually these processes touch each other to form a network of joined cells which lose their independence and beat synchronously. This is accompanied by an increase in the number of beating cells from a small percentage to essentially 100 percent. Figure 2 shows a group of cells attached through extended processes. These cells are all beating at the same rate and in unison. A similar phenomenon was observed by Fischer (*3*), who found that heart tissues from embryonic chick, grown in vitro, showed at first their own rhythmic rate and became synchronous after the two adjacent cultures had fused.

Continued growth is a result of an increase in the number of cells (Fig. 3). As these cells become more confluent, centers of beating are established which consist of many crowded cells. Some of these cells, as shown in Fig. 4, are flat and attached to the glass; others are rounded and attached only to other cells. Beating occurs in the areas indicated by arrows. The flattened cells seem to be oriented in their long axes directed toward the center of beating.

Eventually, as the areas of beating cells grow and become more crowded, some develop into long, thick, fiber-like masses of tissue. These fibers beat strongly at about the same rate as the original beating cells and develop from beating centers by an orientation of the cells along a long axis during their growth, as shown in Fig. 5. A more developed fiber is pictured in Fig. 6. All of the beating on the plate seems to be concentrated in these fibers, as the flattened areas around the fibers do not appear to contract.

More information as to the nature of the communication of beating centers was obtained through a study of the effect of temperature. The beating rate of the connected cells is extremely temperature-dependent. In one representative case, starting at 180 beats per minute at 34°C, the rate fell steadily until it reached 60 beats per minute at 23°C. In another dish, cells at 34°C, beating at a rate of 78, dropped to a level of 24 beats per minute as the temperature dropped to 23°C. These results indicate a Q_{10} of approximately 3. The beating at the higher temperature was a regular, strong contraction in which the whole cell participated. As the temperature was lowered the beating became not only slower but also more irregular. In one representative case the beating started at 78, and when it reached 40 beats per minute a faint after-contraction was observed immediately after each main contraction. This slight twitch of the cellular protoplasm was oriented in a different plane from that of the main contraction and seemed localized in one part of the cell. As the rate further slowed to 25 beats (at 23°C, where it was maintained), a more irregular beating echo occurred which, coupled with the weakened main beat, gave the whole cell an irregular contraction pattern.

The relevant aspect of this change is that the same rhythmic relation of main beat to after-beat occurs in every in-

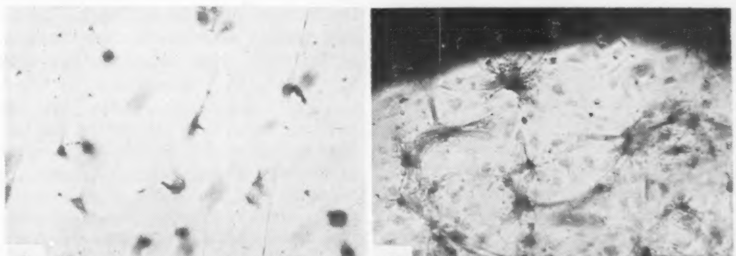

Fig. 1. Single cells beating at independent rates (stained with hematoxylin and eosin) (about × 170). Fig. 2. Individual cells joined through protoplasmic extensions (stained with methylene blue) (about × 170). Fig. 3. Further growth of connected cells (stained with methylene blue) (about × 170). Fig. 4. Beating centers of heart cells (stained with methylene blue) (about × 85). Fig. 5. Beginning of fiber formation (stained with methylene blue) (about × 170). Fig. 6. Beating fiber, unstained (about × 85).

dividual within a group of connected cells, indicating that a system exists which communicates the rate, strength, frequency, and location of the contraction. The pattern of beating may vary from one preparation to another. It may involve one strong and one weak beat, or one strong and two or three weak beats, but in all cases where the cells are joined, the beating of the cells is identical. The intercommunication between cells within such a group of cultured cells does not appear to be of the neuromuscular synaptic type. Flaxedil, a curare-type drug, has no effect on either the rate or the synchrony of the connected beating cells, nor do eserine and acetylcholine affect the synchrony of such preparations.

There are clear indications that physical contact plays a role in the communication of beating. A preparation of freshly suspended heart cells was divided into three unequal aliquots and cultured in equal volumes of media. The first contained X number of cells, the second $3X$, and the third $9X$ number of cells. The dilute or X culture contained single separated cells beating independently. The more concentrated or $3X$ culture contained single cells which were in physical contact. Many areas were examined and found to exhibit beating cells in synchrony, but these areas were not all in synchrony with each other. In the most concentrated, or $9X$, culture all the cells were in contact. Many areas, chosen at random, were examined; they exhibited the same rate of beating, and all these areas were beating in synchrony with each other. It appeared in this culture that all the cells were beating in unison.

The cells in the $9X$ culture were divided into two separate parts by running a needle down the middle of the dish to clear a swath of all cells and dividing the remainder into two groups, both in the same dish and in contact with the same media but not in contact with each other. In two cases, when this was done, it was seen that all the cells within each group beat synchronously but not with those of the other group. The beating rate in one case was 90 on one side and 75 on the other, and in another case 35 on one side and 10 on the other. The two sides were inhibited to different extents by acetylcholine, although the synchrony within each group was not affected.

The fact that single heart cells may be prepared from young heart tissue indicates that the heart exists, at the least, as a tissue potentially composed of mononucleated cells. On the other hand, the development of single cells in culture into sheets of tissue which, when stained, appear to be a syncytium indicates that the dissociation process must be, to an extent, reversible. The communication of physical or chemical events from one beating center to another would be facilitated by the absence of cell membrane barriers. It is also clear that physical contact may also serve to communicate the contractile event. It is obvious, however, that even if neuromuscular synapse mechanisms do not operate, and even though the syncytial form would facilitate communication, we have neither ruled out other synaptic mechanisms, nor explained, on the basis of the syncytium, the extreme rapidity of the communication of beating from one center to another.

The ability of single rat heart cells to grow into beating sheets of cells is, in this case, a process which is not accompanied by loss of function. The continued growth into a beating, fiber-like mass may indicate that these cells have an inherent potential related to the functioning of the intact heart.

The expression of cellular function in a manner which can be quantitatively evaluated provides a system in which such matters as cellular communication, organization, and differentiation may be studied (*4*).

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27 June 1960

Photodynamic Inactivation of Infectious Nucleic Acid

Abstract. Tobacco mosaic virus–infectious nucleic acid causes a color shift when combined with acridine orange, methylene blue, and safranine. A high concentration of acridine orange inactivates infectious nucleic acid even in darkness, while a mixture of nucleic acid with a low concentration of the dye must be exposed to visible light prior to inoculation for inactivation to occur.

Ribonucleic acids can combine with a variety of basic dyes. The combination is assumed to occur between the positively charged chromophore of the dye and the negatively charged phosphate groups of the ribonucleic acid, and can result in a shift in the wavelength of the maximum visible light absorption by the dye. Michaelis (*1*) demonstrated these effects with yeast nucleic acid and the dyes phenosafranine, toluidine blue, thionine, and pyronin, while Oster and Grimsson (*2*) demonstrated a color shift when toluidine blue, methylene blue, and safranine were combined with the nucleic acid released when tobacco mosaic virus is heated above 90°C.

Table 1. Lesions produced on leaves inoculated with nucleic acid and nucleic acid-dye mixture.

Inoculum	Treatment	Lesions (total No.)
Nucleic acid	Light	3043
Nucleic acid	Dark	2381
Nucleic acid and $6.4 \times 10^{-4}M$ dye	Light	0
Nucleic acid and $6.4 \times 10^{-4}M$ dye	Dark	36
Nucleic acid and $1.65 \times 10^{-5}M$ dye	Light	0
Nucleic acid and $1.65 \times 10^{-5}M$ dye	Dark	3190

I have recently observed a similar color shift, readily visible to the naked eye, when the dyes acridine orange, methylene blue, and safranine are combined with infectious nucleic acid from tobacco mosaic virus, prepared by the phenol method of Gierer and Schramm (*3*). Since acridine orange and methylene blue fluoresce in visible light and are therefore potentially capable of photodynamic action (*4*), it seemed of interest to test the effect of visible light on dye-bound infectious nucleic acid.

In a typical experiment, nucleic acid, at 0.1 mg/ml was bound to acridine orange at $6.4 \times 10^{-4}M$ and at $1.65 \times 10^{-5}M$. Dilutions of the nucleic acid and dye were made in $0.1M$, *p*H 7 phosphate buffer. This mixture was either exposed to light of 2300 ft-ca from white fluorescent tubes for 30 minutes or else kept in the dark. The mixtures were kept in iced water throughout, including the period when the test plants of *Nicotiana glutinosa* were inoculated. Each inoculum, containing 50 mg of celite per milliliter as abrasive, was rubbed on at least 72 half-leaves in an incomplete block design (*5*). Local lesions were counted 3 days later, and the results are shown in Table 1.

Even at the high dye concentration, which obviously caused a marked reduction of infectivity in the dark, there is a noticeable additional effect of light. However, at the low dye concentration used, the photodynamic action is extremely striking, since at this concentration there is no demonstrable dark effect, while visible light resulted in a complete abolition of infectivity.

In another experiment where only the dilute dye was used, no photodynamic action could be demonstrated when the mixture was rubbed on leaves prior to illumination.

Oster and McLaren (*6*) have shown that the fluorescent dye, acriflavine, mediates a visible light inactivation of intact tobacco mosaic virus. However, to my knowledge, similar photodynamic action has not previously been demonstrated for infectious nucleic acid (*7*).

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29 August 1960

Temperature and Charge Transfer in a Receptor Membrane

Abstract. The rate of rise and the amplitude of a mechanically elicited generator potential in a receptor membrane (Pacinian corpuscle) increases markedly with temperature. By contrast, the amplitude of the action potential of the Ranvier node adjacent to the receptor membrane remains practically unchanged over a wide range of temperature. The activation energy of the rate-limiting process in excitation of the receptor membrane is high; it indicates the existence of a high potential energy barrier for charge transfer.

Mechanical stimulation of the nerve ending of Pacinian corpuscles produces transfer of charges through its receptor membrane. The energy requirements for the transfer are markedly influenced by temperature. For example, the strength of a mechanical stimulus necessary to produce a given generator potential at 25°C may be reduced to one-third at 35°C. A temperature change alone, however, elicits no detectable transfer.

The experiments reported here were done on single intact Pacinian corpuscles of the cat and on single nerve endings isolated by dissection from the corpuscles (*1*). The receptor ending was stimulated with mechanical pulses of known strength from a piezoelectric crystal, and the resulting electrical activity was led off from the axon or directly from the nerve ending (*2*). Experiments with intact corpuscles and with denuded nerve endings yielded essentially the same results.

The main effect of a temperature change is to vary the rate of rise and the amplitude of the mechanically elicited generator potential (Figs. 1 and 2). The rate of rise and the amplitude of the generator potential in response to a mechanical stimulus of a given (submaximal) strength increase approximately linearly with temperature with a mean Q_{10} of 2.5 and 2.0, respectively (15° to 35°C). The decay time of the generator potential is not appreciably affected by temperature.

The membrane of the first node of Ranvier adjacent to the receptor membrane, the site at which the nerve impulse arises, behaves quite differently. The amplitude of the action potential of the node, like that of other membranes with regenerative excitability (*3*), remains rather constant over a wide range of temperature (20° to 40°C), and its duration increases with temperature with a Q_{10} of 3 or higher. The electrical threshold for firing of impulses at the node varies inversely with temperature; the initiation of impulses at the node fails completely below 12°C, although the receptor membrane still produces generator potentials.

It may be thought that the observed results reflect mechanical effects due to changes in viscosity or rigidity of the preparation rather than effects on the excitation process of the receptor membrane. This possibility seems, however, unlikely. The visco-elastic properties of our preparation—namely, the denuded nerve ending—are not expected to differ from those of aqueous protein jellies whose temperature coefficients of viscosity and rigidity are as low as those of water. For instance, the Q_{10}'s of viscosity of blood plasma (*4*), egg albumin (*5*), and water are all approximately 1.2 between 20° and 40°C.

The energy of activation of the rate-limiting process in receptor excitation, as calculated from the temperature dependence of the rate of rise of the generator potential, is equivalent to 16,300 cal/mole. This reveals that at least at one stage in the excitation process there is a high potential energy barrier for charge transfer. It has been shown that charge transfer increases as a function of the electrical gradients across the receptor membrane (*6*). Thus a simple and, heretofore, quite plausible model for receptor excitation is that of ions diffusing simply along their gradients through mechanically stretched "pores" of the receptor membrane. This model must now be modified. The high activation energy found in our experiments forces at least one additional element, a high energy barrier, upon this or any other model one may prefer to choose. To surmount the barrier, energy may be supplied directly through heat transfer, or indirectly through a mechanically coupled chemical reaction. In any event, the immediate source that supplies the energy to surmount this barrier cannot be identical with the one that serves to trigger the excitation process: excitation, in our experiments, could only be brought about by mechanical stimulation; heat transfer alone, however steep its gradients, was found to be ineffective in exciting charge transfer.

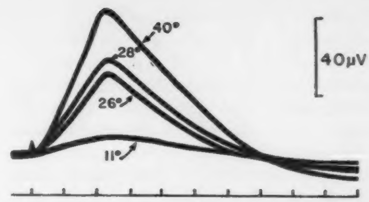

Fig. 1. Effect of temperature on charge transfer through a receptor membrane. The nerve ending is stimulated with equal mechanical pulses from a piezoelectric crystal, and the resulting generator potentials at various temperatures are superimposed. Time calibration, 1 msec.

Receptor excitation is thus thought to operate according to one of the following schemes. (i) The mechanical stimulus causes a directly coupled increase in permeability of the receptor membrane, and ions flow across the membrane along their electrochemical gradients, after overcoming an energy

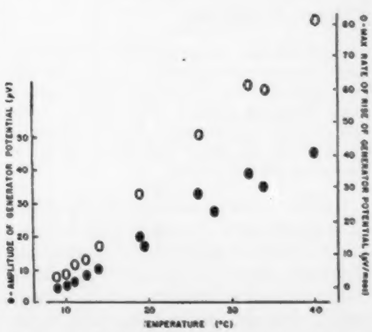

Fig. 2. Amplitude and rate of rise of generator potential as a function of temperature. The nerve ending is stimulated with equal mechanical pulses, and the mean amplitude and rate of rise of the resulting generator potential are determined at various temperatures.

barrier. A nonmechanical source provides the immediate energy to overcome the barrier. (ii) The mechanical stimulus activates a chemical reaction of about 16,300 cal of activation energy per mole, which in turn causes the permeability of the membrane to increase and ions to flow along their gradients (*7*).

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7. This work was aided by research grants from the National Science Foundation and the National Institute of Neurological Diseases and Blindness (grant No. B-1466).

* On leave of absence from Kumamoto University Medical School, Kumamoto, Japan.

2 September 1960

Frequency of Mutations Induced by Radiations in Hexaploid Species of Triticum

Abstract. The frequency of visible mutations induced by x-rays, phosphorus-32, and sulfur-35 was calculated in six hexaploid *Triticum* species. The species with spelted ears and winter habit showed a much lower mutation rate than the free-threshing, spring wheats.

Results from mutation experiments carried out during recent years in several countries in varieties of bread wheat (*Triticum aestivum* L.; $2n = 42$) have borne out Gustafsson's (*1*) statement that in this species "with suitable x-ray doses a mass mutating sets in." MacKey (*2*) has shown that over 30 percent of the mutations isolated in the progenies of irradiated plants of bread wheat result from either the loss or the duplication of the speltoid suppressor gene *Q* situated in the distal end of the long arm of chromosome IX [chromosome 5A according to the new system of nomenclature proposed by Sears (*3*)]. the hexaploid wheats, *T. spelta* L., *T. macha* Dek. et Men., and *T. vavilovi* Jakub., lack the *Q* factor; hence an experiment was undertaken for finding out the frequency and types of mutations induced by radiations in *T. aestivum* L., *T. compactum* Host., *T. sphaerococcum* Perc., *T. spelta* L., *T. macha* Dek. et Men., and *T. vavilovi* Jakub., the six commonly recognized hexaploid species. One stable and homogenous strain was chosen in each species; the *T. aestivum* and *T. macha* varieties used were awned and the rest were awnless. The *T. aestivum*, *T. compactum*, and *T. sphaerococcum* varieties were spring types, while the others had a winter habit.

Table 1. Frequency of mutations observed in the M_2 generation in *Triticum* species.

Speoies	Total M_2 families (No.)	M_2 families segregating for mutants (No.)	M_2 plants studied (No.)	Mutations in M_2 generation (No.)	Mutation rate (%)	
					Segregating families	Mutations per M_2 family
T. aestivum	338	88	6103	206	26.04	60.95
T. compactum	337	92	6335	253	27.30	75.07
T. sphaerococcum	333	82	6106	219	24.62	65.77
T. spelta	346	27	3390	36	7.80	10.40
T. macha	190	4	1987	13	2.11	6.84
T. vavilovi	147	3	1556	5	2.04	3.40

Dry seeds (5 to 6 percent moisture content) were treated with x-rays (11,000 and 16,000 r), phosphorus-32 (5 μc per seed), and sulfur-35 (5 μc per seed). One hundred seeds were used in each treatment, and the treated seeds were planted in the field along with the respective controls. The main tiller and one or two more tillers of each plant were selfed, and the second generation progenies were raised the following year by sowing the seeds from each plant in individual rows. While no visible mutations occurred in the control material, many such mutations were found in the progenies of treated plants. The population was scored for all phenotypically detectable mutations, and the mutation frequencies observed in the different species were calculated both in terms of the percentage of M_2 families segregating for mutations and the percentage of mutants per M_2 family (Table 1). Since the trend in the frequency and spectrum of mutations induced by the different treatments was similar in all the species, the pooled data are given in Table 1.

Statistical analysis showed that *T. spelta*, *T. macha*, and *T. vavilovi* had a significantly lower mutation frequency than *T. aestivum*, *T. compactum*, and *T. sphaerococcum*. The differences between species within each of these two groups were not significant. It is now known that *T. spelta*, *T. sphaerococcum*, and *T. compactum* are each separated from *T. aestivum* by a single gene: *Q* located on chromosome IX (5A), *S* on XVI (3D), and *C* on XX (2D), respectively (*4*). The number and location of the genes differentiating *T. macha* and *T. vavilovi* from *T. aestivum* have not yet been precisely determined, though there is evidence to suggest that only one or two genes may be involved in these cases also (*5*). A study of the relative frequencies of different types of mutations found during the present study in each species revealed that 31.07, 39.92, and 63.93 percent, respectively, of the mutations isolated in *T. aestivum*, *T. compactum*, and *T. sphaerococcum* could be attributed to the loss or duplication of the appropriate species differentiating locus (that is, *Q*, *C*, or *S*). The mutations found in *T. spelta* related mostly to awning or ear density, while a change to the *T. aestivum* type of ear and internode structure was the only type of mutation recorded in *T. macha* and *T. vavilovi*. Visible mutations can occur in a polyploid only at loci in which phenotypic buffering induced by duplications does not exist (*6*). These results suggest that the number of such loci, while generally few in hexaploid *Triticum* species, is relatively more in the free-threshing spring wheats (*7*).

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7. We are indebted to Drs. B. P. Pal and A. B. Joshi for their advice and interest.

6 September 1960

Association Affairs

American Geophysical Union Program on the Impact of Space Research on the Sciences

During the New York meeting of the AAAS the American Geophysical Union will hold a symposium, cosponsored by Section D–Astronomy and the American Astronomical Society, on the impact of space research on the sciences. The program was arranged by the AGU's planning committee on planetary science, Robert Jastrow (National Aeronautics and Space Administration), secretary; it will be held in the Biltmore Hotel at 2 P.M., 28 Dec. E. M. Purcell of Harvard University (on leave, at Brookhaven National Laboratory) will preside.

Papers will be presented on the interaction between the earth sciences and planetary studies (Gordon J. F. MacDonald, Goddard Space Flight Center, National Aeronautics and Space Administration); planetary environments and extraterrestrial life (Philip Abelson, Geophysical Laboratory, Washington, D.C.); and flying telescopes (Martin Schwarzschild, Princeton University).

Topical Summary of Symposia To Be Held at the New York Meeting

AAAS General Symposia. "Moving Frontiers of Science V"; "The Challenge to Science of World Conditions Today"; "Plasma—the Fourth State of Matter"; "Life under Extreme Conditions: Human Studies"; "The Urban Frontier: a Conquest of Inner Space."

AAAS and Conference on Scientific Communication et al. "The Sciences in Communist China: Mathematics and the Physical Sciences; Meteorology, Oceanography, and the Engineering Sciences; Astronomy and the Biological and Medical Sciences; Agriculture and the Social Sciences."

AAAS Committee on Science in the Promotion of Human Welfare. "The Scientist's Role in the Community: New Responsibilities in the Nuclear Age"; "Psychological and Sociological Implications of Nuclear Arms"; "Problems Related to the Expansion of Medical Research"; "The Effects of the Present Status of Science on the Integrity of Science."

AAAS Cooperative Committee on the Teaching of Science and Mathematics. "Progress in Teacher Certification in Science"; "Science Education in the Elementary and Junior High Schools."

Academy Conference. "The Utilization of National Science Foundation Grants by the Academies of Science."

Conference on Scientific Manpower. "Developing Student Interest in Science and Engineering."

Mathematics. "The Mathematics Course on 'Continental Classroom' "; "Mathematics Looks at New Problems"; "Vistas in Digital Computing."

Space Science. "Impact of Space Research on the Sciences"; "Lunar Exploration"; "Lunar Spacecraft Systems"; "Is There a Need for a Manned Space Laboratory?"

Physics Engineering. "The Place of Nuclear Engineering in the University Curriculum."

Chemistry. "Mechanism of Action of Antitumor Agents"; "Recent Advances in Polymer Chemistry"; "Synthetic Zeolites"; "Reaction of Complexes"; "Biochemical Applications of Gas Chromatography."

Geology and Geography. "Palynology"; "Frontiers in the Earth Sciences"; "The Mohole"; "Selenology"; "Late Pleistocene Events in Southern South America"; "Soviet Geography"; "The New York Metropolitan Region of the Future"; "Economic Development and Investment in Africa South of the Sahara"; "Programming the Use of Natural Resources"; "Cave Mineralogy."

Zoological Sciences. "Evolution and Dynamics of Vertebrate Feeding Mechanisms"; "Evolution of Sex"; "Spermatozoan Motility"; "Physiology of Molluscs"; "Teaching Animal Behavior"; "Famous Zoologists"; "The New International Code of Nomenclature."

Biological Sciences. "Life Under Extreme Conditions: Cells; Plants and Animals; Human Studies"; "Unsolved Problems in Biology, 1960: Submicroscopic Cellular Structure and Function"; "Modern Aspects of Population Biology"; "Physiological Adaptations of Cavernicolous Organisms"; "Phylogenetic Aspects of Evolution"; "Genetic Aspects of Evolution"; "Speciation and Variation"; "Ecological Aspects and Methods"; "Machine Methods in Biology."

Botanical Sciences. "Fundamental Developments in Plant Growth."

Anthropology. "Genetics, Evolution, and Anthropology"; "Ecology and Anthropology: Interdisciplinary Approach to Methods of Implementing Desegregation"; "Applied Anthropology: Retrospect and Prospect"; Archeological Salvage"; "The Development of New Nations"; "Language and Cognition"; "Theories and Models of Energy in Human Society."

Psychology. "The Physiology of Feeding and Drinking Behavior"; "Some Recent Approaches to the Learning of Concepts"; "Applications of Behavior Technology"; "Theories of the Visual Contrast Threshold."

Social and Economic Sciences. "The Economics of Science"; "Some Perspectives on Political Science and Science"; "Sociology of Science: Organization of Research"; "Population Trends and Policies in the Communist Countries"; "Hospital Statistics in Community Planning"; "Some Statistical Problems in Social Insurance Research"; "The Current Interest in the Adoption of the Metric System"; "The Research Revolution and Public Policy."

Criminology. "Psychiatry, Criminology, and the Offender"; "New Approaches to Continuing Problems in Crime Control"; "Reaching the Antisocial Gang"; "Research and Theory in Criminology and Penology."

History and Philosophy of Science. "Patents in the Advancement of Knowledge"; "Fairly Recent Science and Technology"; "Sociology and Psychology of Scientists"; "The Scientific Mainstream"; "Formal Simplicity as a Weight in the Acceptability of Scientific Theories"; "The Boundaries of Systems"; "Nineteenth Century Technology"; "Automation."

Medical Sciences. "Biophysics of Physiological and Pharmacological Actions: Elementary Systems, Nerve, Muscle I: Membrane Properties, Muscle II: Contractile Properties, Muscle III"; "Current Problems in Electrobiology"; "Career Opportunities in Medicine and Dentistry"; "Expression of the Emotions in Man."

Dentistry. "Fundamentals of Keratinization."

Pharmacy. "The Scientist's Contribution to the Safe Use of Cosmetics."

Agriculture. "Land Zoning in Relations to Agricultural, Suburban, Industrial, Forest, and Recreational Needs of the Future: Rural Land Zoning; Suburban Planning; The Urban Frontier: a Conquest of Inner Space; Community Planning; Forest and Recreational Planning; Government as Land-Owner and Redistributor."

Industrial Science. "Management Science."

Education. "Data Processing Machines and Educational Research"; "Some Implications of Project Talent for the Identification and Development of Future Scientists"; "Interrelated Problems of Automated Teaching and Evaluation"; "Research Symposium."

Science Teaching. "The Experimental Approach"; "Outdoor Laboratories"; "Glaciation—Past and Present"; "The New Science—a Teaching Challenge: The New Chemistry; The New Astronomy; The Planet Earth; Recent Developments in Meteorology; Biology of the Mind; Biology and Audiovisual Education"; "Pet Nature Projects of Members"; "New Approaches, Techniques, Equipment, Uses, and Evaluation of Nature Photography"; "Writing, Illustrating and Publishing for the Nature Audience."

Meetings

Forthcoming Events

January

3–9. Indian Science Cong., 48th session. Roorkee (Uttar Pradesh), India. (General Secretary, ISC Assoc., 64 Dilkhusa St., Calcutta 17, India)

8–12. Thermoelectric Energy Conversion, symp., Dallas, Tex. (P. H. Klein, General Electric Co., Electronics Lab., Bldg. 3, Room 221, Syracuse, N.Y.)

8–13. American Acad. of Orthopedic Surgeons, Miami Beach, Fla. (J. K. Hart, 116 South Michigan Ave., Chicago 3, Ill.)

8–14. Bahamas Conf. on Hypertension, Nassau. (I. M. Wechsler, P.O. Box 1454, Nassau)

8–14. International Conf. of Social Work, 10th, Rome. (Miss R. M. William, ICSW, 345 E. 46 St., Room 1012, New York 17)

8–15. Latin American Convention of Astronomy, 2nd, Lima, Peru. [A. C. Parro, Enrique Palacios 187 (359), Chorrillos (Lima), Peru]

9–11. Reliability and Quality Control, 7th natl. symp., Philadelphia, Pa. (R. L. Schwerin, ACF Electronics Div., ACF Industries, Inc., 11 Park Place, Paramus, N.J.)

9–12. White House Conf. on Aging, Washington, D.C. (Special Staff on Aging, Office of the Undersecretary, Dept. of Health, Education and Welfare, Washington 25)

9–13. Society of Automotive Engineers, annual, Detroit, Mich. (SAE, 485 Lexington Ave., New York 17)

10–11. Conference on Physics of Polymers, Bristol, England. (Organizing Secretary, Physical Soc., 1 Lowther Gardens, London, S.W.7)

16–18. American Astronautical Soc., annual, Dallas, Tex. (F. F. Martin, AAS, 304 S. Woodstock Dr., Haddonfield, N.J.)

16–19. Instrument Soc. of America, winter instrument-automation conf., St. Louis, Mo. (W. H. Kushnick, 313 Sixth Ave., Pittsburgh 22, Pa.)

22–28. Bahamas Serendipity Conf., 3rd, Nassau. (I. M. Wechsler, P.O. Box 1454, Nassau)

23–25. Institute of the Aeronautical Sciences, 29th annual, New York, N.Y. (Meetings Dept., IAS, 2 E. 64 St., New York 21)

23–26. American Meteorological Soc., 41st annual, New York, N.Y. (K. C. Spengler, AMS, 45 Beacon St., Boston 8, Mass.)

24–27. American Mathematical Soc., 67th annual, Washington, D.C. (J. W. Green, Univ. of California, Los Angeles)

24–27. Society for Industrial and Applied Mathematics, Washington, D.C. (G. Kaskey, Remington Rand Univac, 1900 W. Allegheny Ave., Philadelphia, Pa.)

24–27. Society of Plastics Engineers, 17th annual conf., Washington, D.C. (T. A. Bissell, SPE, 65 Prospect St., Stamford, Conn.)

25–27. Mathematical Assoc. of America, annual, Washington, D.C. (H. L. Alder, Dept. of Mathematics, Univ. of California, Davis)

26–27. Western Spectroscopy Conf., 8th annual, Pacific Grove, Calif. (R. C. Hawes, Applied Physics Corp., 2724 S. Peck Rd., Monrovia, Calif.)

27–28. Royal College of Physicians and Surgeons, annual, Ottawa, Ontario, Canada. (T. J. Giles, 150 Metcalfe St., Ottawa)

28–30. Control of the Mind, symp., San Francisco, Calif. (Dept. of Continuing Education in Medicine, Univ. of California Medical Center, San Francisco 22)

28–31. Infertility, sectional meeting, Intern. Fertility Assoc., Acapulco, Mexico. (M. L. Brodny, 4646 Marine Dr., Chicago 40, Ill.)

29–3. American Inst. of Electrical Engineers, winter meeting, New York, N.Y. (E. C. Day, AIEE, Technical Operations Dept., 33 W. 39 St., New York 18)

30–3. Clinical Cong. of Abdominal Surgeons, Miami Beach, Fla. (B. F. Alfano, 663 Main St., Melrose 76, Mass.)

30–4. American Library Assoc., midwinter meeting. (Mrs. F. L. Spain, New York Public Library, 20 W. 53 St., New York, N.Y.)

31–4. American Assoc. of Physic Teachers, New York, N.Y. (F. Verbrugge, 135 Main Engineering, Univ. of Minnesota, Minneapolis)

31–4. American Physical Soc., annual, New York, N.Y. (K. Darrow, APS, Columbia Univ., 116th St. and Broadway, New York)

February

1–3. Solid Propellant Rocket Conf., American Rocket Soc., Salt Lake City, Utah. (R. D. Geckler, Aerojet-General Corp., P.O. Box 1947, Sacramento, Calif.)

1–3. Winter Military Electronics Conv., 2nd, Inst. of Radio Engineers, Los Angeles, Calif. (A. N. Curtiss, IRE Business Office, 1435 S. La Cienega Blvd., Los Angeles 35)

1–4. American Physical Soc., annual, New York, N.Y. (K. K. Darrow, APS, 538 W. 120 St., New York 27)

2–4. Congress on Administration, 4th annual, Chicago, Ill. (R. E. Brown, American College of Hospital Administrators, 840 N. Lake Shore Dr., Chicago 11)

6–8. American Acad. of Allergy, 17th annual, Washington, D.C. (J. O. Kelly, 756 North Milwaukee St., Milwaukee 2, Wis.)

6–8. Geodesy in the Space Age, symp., Ohio State Univ., Columbus. (W. A. Heiskanen, Ohio State Univ., 1314 Kinnear Road, Columbus 12)

9–15. Second Allergy Conf., Nassau, Bahamas. (I. M. Wechsler, P.O. Box 1454, Nassau)

13–16. American Soc. of Heating, Refrigerating and Air-Conditioning Engineers, Chicago, Ill. (R. C. Cross, 234 Fifth Ave., New York 1)

15–17. International Solid-State Circuits Conf., Philadelphia, Pa. (J. J. Suran, Bldg. 3, Room 115, General Electric Co., Electronics Park, Syracuse, N.Y.)

22–25. American Educational Research Assoc., annual, Chicago, Ill. (G. T. Buswell, 1201 16th St., NW, Washington 6)

23-25. American Orthopsychiatric Assoc., annual, New York, N.Y. (Miss M. F. Langer, 1790 Broadway, New York 19)

23-25. Fifteenth Annual Symp. on Fundamental Cancer Research, Houston, Tex. (Publications Dept., Univ. of Texas M.D. Anderson Hospital and Tumor Inst., Texas Medical Center, Houston 25)

New Products

The information reported here is obtained from manufacturers and from other sources considered to be reliable. Neither Science *nor the writer assumes responsibility for the accuracy of the information. All inquiries concerning items listed should be addressed to the manufacturer. Include the department number in your inquiry.*

■ EIGHT-CHANNEL RECORDER can be set up, by means of plug-in modules, to accommodate a variety of input signals. Frequency response is ±1 percent from d-c to 110 cy/sec. Full-scale trace amplitude is 4 cm. A carbon-transfer method of writing is said to produce an exceptionally thin line that is permanent and reproducible by all conventional processes. The recording stylus is dithered at a frequency of 400 cy/sec with imperceptible amplitude to eliminate friction and static error. Chart speed can be changed by push-button selection between 0.1 and 500 mm/sec. (American Optical Co., Dept. Sci959, Buffalo 15, N.Y.)

■ PARAMETRIC AMPLIFIER provides instantaneous band width of 35 to 40 Mcy/sec, over-all noise figure of 2.0 db, and gain of 20 db. It is available at customer-specified center frequencies in the 500 to 1000 Mcy/sec range. (Varian Associates, Dept. Sci969, 611 Hansen Way, Palo Alto, Calif.)

■ FLOW TRANSDUCER for use with orifice plates, flow tubes, or weirs utilizes an opposed-bellows meter body together with a precision potentiometer winding to provide an output signal directly proportional to flow. Characterization is accomplished by tapping and shunting the winding to the specific curve desired. Total resistance values from 500 to 5000 ohms are available. Differential pressure ranges from 0 to 20 in. of water to 5000 lb/in.^{2} can be provided. Between 20 and 100 percent of flow, resolution is said to be within 0.1 percent and linearity within ±0.5 percent of total flow for all ranges above 0 to 50 in. of water. (H. E. Sostman & Co., Dept. Sci960, 347 E. Lincoln Ave., Cranford, N.J.)

■ SIGNAL GENERATOR provides continuous-wave, frequency-modulated, and pulse-modulated radio-frequency energy continuously tunable over the range 4200 to 11000 Mcy/sec. Repetition rate is variable from 10 to 10,000 pulses per second, and delay is variable from 2 to 2000 μsec. A self-contained modulator provides pulse widths said to be as small as 0.2 μsec. Output is 1 mv calibrated. Tuning dial accuracy is ±1 percent. (Polarad Electronics Corp., Dept. Sci963, 43-20 34 St., Long Island City 1, N.Y.)

■ ELECTROLYTIC HYGROMETER CELL for measurement of the moisture content of hydrogen streams is designed to eliminate errors attributed to recombination of the electrolytically generated oxygen with the hydrogen stream. The cell, recommended by the manufacturer for measurements when hydrogen concentration is greater than 50 percent, is said to be capable of removing and electrolyzing most of the water with an insignificant amount of recombination. (Beckman Instruments, Inc., Dept. Sci967, 2200 Fullerton Rd., Fullerton, Calif.)

■ PLASMA SPRAY GUN conversion kit permits the modification of SG-1 hand-held plasma spray gun to variable arc temperature. The kit permits adjustment of the jet temperature between +300°F and +30,000°F as follows: the distance the adjustable rear electrode projects into the throat of the front electrode is changed by adjustment of the insulated rod to which the rear electrode is mounted. The closer the arc to the injection point the hotter the jet temperature at injection. (Plasmadyne Corp., Dept. Sci968, 3839 S. Main St., Santa Ana, Calif.)

JOSHUA STERN
National Bureau of Standards, Washington, D.C.

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(a) **Biochemist;** Ph.D.; $12,000 and (b) **Bacteriologist;** M.S., Ph.D.; $9000. Head respective divisions, newly reorganized laboratory, 250-bed approved general hospital; lovely southeastern location; excellent potential. (c) **Bacteriologist;** M.S., equivalent; clinical experience; approved technology school; 250-bed general hospital in lovely Chicago suburb; $7500. (d) **Biochemist;** Ph.D. capable independent study; California pharmaceutical company; to $9600. (e) **Biochemist;** M.S., Ph.D.; full charge busy department, 500-bed general hospital; $6500 minimum; vicinity New York City. (f) **Biochemist** and (g) **Bacteriologist;** 3–5 years of hospital experience respectively; head departments, fully approved 400-bed general hospital; university, industrial center; Northeast. (h) **Bacteriologist;** M.S. preferred for busy department, several teaching programs, expanding facilities; 300-bed facility; lovely southeastern capital city; $6000 up. (i) **Biochemist;** new, air-conditioned laboratory, expansion program under way; 300-bed general hospital; to $9600; industrial city near Chicago. (j) **Pharmacologist;** M.D., Ph.D., trained neurophysiology, neuropharmacology; university staff appointment, well-furnished laboratory, research opportunity; must be capable independent investigation; to $10,000; Southeast. Science Division, Woodward Medical Bureau, Ann Woodward, Director, 185 North Wabash, Chicago. X

BIOPHYSICISTS & BIOCHEMISTS—

Basic research institute (East Coast) with several programs in the physical sciences desires to intensify and expand the biosciences group. Current program includes photochemistry, photosynthesis and related aspects of physical and chemical biology. Positions and salaries commensurate with training and experience. Postdoctoral fellowships also available. Send résumé and salary requirements to: Box 224, Science, 1515 Mass. Ave., NW, Washington 5, D.C.

POSITIONS OPEN

(a) **Clinical Biochemist** for active 250-bed hospital near Appalachian Mountain range; $12,000; Southeast. (b) **Biology Teacher** for private college; East. (c) **Genetic Scientist** for cancer research at university-affiliated institute; $8000–$10,000; East. (d) **Physiologist** to study effects of whole-body vibration and physiological response at human factor laboratory; $7500 up; additional university affiliation possible; Midwest. (e) **Bacteriologist** to head department in new 350-bed hospital expanding to 450 beds; California. (f) **Virologist** trained in tissue culture for tumor virus research at large medical center with new facilities; East. (g) **Biochemist** trained in chromatographic, electrophoretic techniques for research on Hodgkins Disease; around $10,000; Southwest. (h) **Immunochemist** for allergy research and independent studies of enzyme systems in peanuts and other projects at experimental station; university rank; around $9000; South. (i) **Biologist** for research on environmental radioactive contamination at nuclear medical center; $7000–$10,000; West. (j) **Immunologist** qualified in biological methods for detecting antigens in tumor research; $10,000; Southeast. (k) **Senior Pharmacologist** with creative ability for chemosynthetic research with large drug firm; $12,000–$15,000; East. (l) **Physiologist/Bacteriologist** to take charge of new electron microscopy department of medical research institute; Midwest. (m) **Chemist** to supervise toxicological laboratory of large city morgue; around $9000; Midwest. (n) **Bacteriology-Public Health Professor** to develop virology teaching and research program at large university; around $9000; East. (Please write for details; also many other positions available through our nationwide service.) S12-3 Medical Bureau, Inc., Science Division, Burneice Larson, Chairman, 900 North Michigan Avenue, Chicago. X

The Boreal Institute of the University of Alberta invites applications for the position of **Executive Director.**

The Executive Director will be a full-time appointee who will aid the Directorate in planning the activities of the institute, implement the decisions of the Directorate, administer the daily operations of the institute, solicit funds for the advancement of the institute, and publicize the activities and accomplishments of the institute.

Applicants must have an interest in the North, administrative ability, ability to deal with the public, and fluency in written and spoken English. Applicants should be willing and able to travel in the North and should have some experience in the North.

Applicants must include a complete résumé of experience, educational background, references, other pertinent data, and a recent photograph.

The appointment will be effective 1 April 1961. Salary is dependent upon qualifications, but will be in the range $8000–$12,000 per year. Applications should be submitted to reach the Boreal Institute, University of Alberta, Edmonton, Alberta, Canada, prior to **1 February 1961.** Applications will be held in confidence if desired. X

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Write Dr. R. E. Olson, Chairman, Department of Biochemistry and Nutrition, Graduate School of Public Health, University of Pittsburgh, Pittsburgh 13, Pa. 12/9, 16

IMMUNOLOGIST

Male-female, M.S. or recent Ph.D. Background tissue culture; genetics desirable. Send résumé Dr. H. Gordon,

Saint Barnabas Medical Center
High St.
Newark, N.J.

MICROBIOLOGY

Applications are invited for the position of professor of microbiology and head of the department, from 1 September 1961. The salary floor is $12,000.

Application should be made to the Dean of Arts and Science, University of Manitoba, Winnipeg, Manitoba, Canada, and should include curriculum vitae, list of publications, and names of three referees.

PHYSICAL-BIOCHEMIST

Prospective or recent Ph.D., as collaborator in studies of protein denaturation at Massachusetts Institute of Technology. Excellent salary, appointment renewable for several years. P.O. Box 2176, Potomac Station, Alexandria, Virginia.

POSITIONS OPEN

AUSTRALIA

The University of New South Wales
Senior Lecturer/Lecturer in Scientific Thought

The University invites applications for appointment to the position of SENIOR LECTURER/LECTURER in SCIENTIFIC THOUGHT in the School of Philosophy, Kensington.

Salary: Senior Lecturer: £A2579 range £A3029 per annum. Lecturer: £A1759 range £A2464 per annum.

Commencing salary according to qualifications and experience.

Applicants for the position of Lecturer must possess a degree with honors in either philosophy or a natural science, and ought to have substantial qualifications in these fields; for appointment to the position of Senior Lecturer, applicants must possess a higher degree or equivalent qualifications. The successful applicant will undertake teaching of scientific thought to students in the Faculty of Arts and may also conduct courses in history and philosophy of science to students in faculties other than Arts.

Appointee will be eligible for 12 months' study leave on full salary after 6 years of service.

Subject to passing a medical examination, the appointee will be eligible to contribute to the State Superannuation Fund.

First-class ship fare to Sydney of appointee and his family will be paid.

Four copies of applications, together with the names of two referees, should be lodged with the Agent General for New South Wales, 56 Strand, London, W.C.2, and a copy forwarded by airmail in an envelope marked "University Appointment" to the Bursar, The University of New South Wales, Box 1, Post Office, Kensington, New South Wales, Australia, before *31 January 1961*

MATHEMATICS

Applications are invited for two appointments in mathematics: **Assistant Professor** ($7500) and **Associate Professor** ($9000). Letters should include curriculum vitae and the names of three referees. They should be forwarded to J. W. Lawson, Head of the Department of Mathematics, University of Manitoba, Winnipeg, Manitoba, Canada. The appointment will commence **1 September 1961.**

SCIENTIST

Wide background in science, preferably biology. Some training in humanities and/or social sciences desirable. Teaching in general education program in large midwestern university. Opportunity for research; emphasis on teaching. Instructor/assistant professor level.

Box 223, SCIENCE

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TEACHING ASSISTANTSHIPS

for Ph.D. candidates beginning 1 September. Annual stipends up to $3200. Research in red blood cell chemistry, enzyme chemistry, plant biochemistry, protein physical chemistry, lipid metabolism, clinical chemistry. Write to Head, Department of Biochemistry, University of Alberta, Edmonton, Canada. 12/16, 23 30

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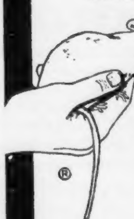

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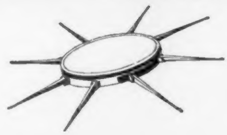
NASA program-highlights

NEXT DECADE IN SPACE

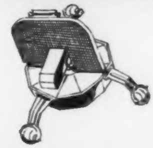
Year 4 to 14 of the Space Age

Project Mercury—U. S.'s first manned satellite.

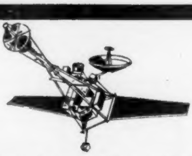
Project Surveyor—First soft landing on moon. Conduct observations from stationary position.



Project Prospector—Soft landing on moon and exploration of area within 50 miles of landing point.

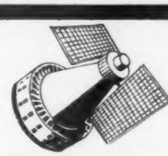


Solar Observatory—350 lb. Large flywheel and extended arms rotate to stabilize. Under construction.

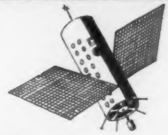


Project Mariner—600 to 1200 lbs. First U. S. Planetary missions to Venus and Mars. Modified craft for hard landings on moon.

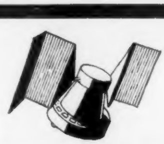
Project Voyager—Orbit Mars and Venus and eject instrumented capsule for atmospheric entry and perhaps landing.



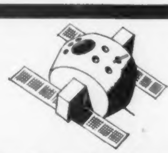
Nimbus—600 to 700 lb. meteorological satellite series. Stabilization system will keep cameras pointed earthward.



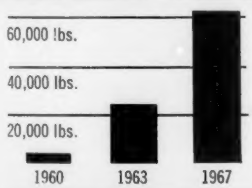
Orbiting Geophysical Observatory—1000 lb. geophysical research satellite designed for a near earth circular polar orbit or an inclined highly elliptical orbit.



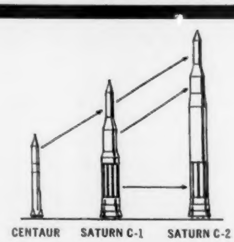
Project Aeros—24-hour stationary weather satellite. Launched in equatorial orbit. Three satellites could permit continuous observation of most of earth's surface.



Orbiting Astronomical Observatory—Standardized, 3500 lb. satellite, for several experiments with different scientific sensors and specialized devices.



Anticipated Growth of NASA Spacecraft in terms of weight of individual near earth satellites.



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NASA Langley Research Center • Hampton, Virginia

NASA Lewis Research Center • Cleveland 35, Ohio

NASA Marshall Space Flight Center • Huntsville, Alabama

NASA Wallops Station • Wallops Island, Virginia

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